BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

PCT

WORLD INTELLECTUAL PROPE
International Bu

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

WO 9605225A1

(51) International Patent Classification 6 :
C07K 14/705, 16/00, C12N 15/09, C12P 1/00, A61K 38/17

A1

(11) International Publication Number: WO 96/05225

(43) International Publication Date: 22 February 1996 (22.02.96)

(21) International Application Number: PCT/US94/09051

(22) International Filing Date: 10 August 1994 (10.08.94)

(71) Applicant *(for all designated States except US)*: HUMAN GENOME SCIENCES, INC. [US/US]; Suite 300, 9620 Medical Center Drive, Rockville, MD 20850-3358 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: SOPPET, Daniel, R. [US/US]; 14310 Winding Woods Court, Centreville, VA 22020 (US). LI, Yi [CN/US]; 16125 Howard Landing Drive, Gaithersburg, MD 20878 (US). ADAMS, Mark, D. [US/US]; 15205 Dufief Drive, North Potomac, MD 20878 (US).

(74) Agents: OLSTEIN, Elliot, M., et al.; Carella, Byrne, Bain, Gilfillan, Cecchi, Stewart &, Olstein:, 6 Becker Farm Road, Roseland, NJ 07068 (US).

(81) Designated States: AU, CA, CN, JP, KR, NZ, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: ADRENERGIC RECEPTOR

(57) Abstract

A human adrenergic receptor polypeptide and DNA (RNA) encoding such polypeptide and a procedure for producing such polypeptide by recombinant techniques is disclosed. Also disclosed are agonists for the adrenergic receptor polypeptide which may be used therapeutically to stimulate the adrenergic receptor and antagonist inhibitors against such adrenergic receptor polypeptides and their use therapeutically to antagonize the adrenergic receptor.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

ADRENERGIC RECEPTOR

This invention relates to newly identified polynucleotides, polypeptides encoded by such polynucleotides, the use of such polynucleotides and polypeptides, as well as the production of such polynucleotides and polypeptides. More particularly, the polypeptide of the present invention is a human 7-transmembrane receptor. The transmembrane receptor is a G-protein coupled receptor. More particularly, the 7-transmembrane receptor has been putatively identified as an adrenergic receptor. The invention also relates to inhibiting the action of such polypeptides.

It is well established that many medically significant biological processes are mediated by proteins participating in signal transduction pathways that involve G-proteins and/or second messengers, e.g., cAMP (Lefkowitz, Nature, 351:353-354 (1991)). Herein these proteins are referred to as proteins participating in pathways with G-proteins or PPG proteins. Some examples of these proteins include the GPC receptors, such as those for adrenergic agents and dopamine (Kobilka, B.K., et al., Pnas, 84:46-50 (1987); Kobilka, B.K., et al., Science, 238:650-656 (1987); Bunzow, J.R., et al., Nature, 336:783-787 (1988)), G-proteins themselves, effector proteins, e.g., phospholipase C, adenyl cyclase, and

phosphodiesterase, and actuator proteins, e.g., protein kinase A and protein kinase C (Simon, M.I., et al., Science, 252:802-8 (1991)).

For example, in one form of signal transductions, the effect of hormone binding is activation of an enzyme, adenylate cyclase, inside the cell. Enzyme activation by hormones is dependent on the presence of the nucleotide GTP, and GTP also influences hormone binding. A G-protein connects the hormone receptors to adenylate cyclase. G-protein was shown to exchange GTP for bound GDP when activated by hormone receptors. The GTP-carrying form then binds to an activated adenylate cyclase. Hydrolysis of GTP to GDP, catalyzed by the G-protein itself, returns the G-protein to its basal, inactive form. Thus, the G-protein serves a dual role, as an intermediate that relays the signal from receptor to effector, and as a clock that controls the duration of the signal.

The adrenergic receptors comprise one of the largest and most extensively characterized families within the G-protein coupled receptor "superfamily". This superfamily includes not only adrenergic receptors, but also muscarinic, cholinergic, dopaminergic, serotonergic, and histaminergic receptors. Numerous peptide receptors include glucagon, somatostatin, and vasopressin receptors, as well as sensory receptors for vision (rhodopsin), taste, and olfaction, also belong to this growing family. Despite the diversity of signalling molecules, G-protein coupled receptors all possess a similar overall primary structure, characterized by 7 putative membrane-spanning α helices (Probst et al., 1992). In the most basic sense, the adrenergic receptors are the physiological sites of action of the catecholamines, epinephrine and norepinephrine. Adrenergic receptors were initially classified as either α or β by Ahlquist, who demonstrated that the order of potency for a series of agonists to evoke a physiological response was distinctly

different at the 2 receptor subtypes (Ahlquist, 1948). Functionally, α adrenergic receptors were shown to control vasoconstriction, pupil dilation and uterine inhibition, while β adrenergic receptors were implicated in vasorelaxation, myocardial stimulation and bronchodilation (Regan et al., 1990). Eventually, pharmacologists realized that these responses resulted from activation of several distinct adrenergic receptor subtypes. β adrenergic receptors in the heart were defined as β_1, while those in the lung and vasculature were termed β_2 (Lands et al., 1967).

α Adrenergic receptors, meanwhile, were first classified based on their anatomical location, as either pre or post-synaptic (α_2 and α_1, respectively) (Langer et al., 1974). This classification scheme was confounded, however, by the presence of α_2 receptors in distinctly non-synaptic locations, such as platelets (Berthelsen and Pettinger, 1977). With the development of radioligand binding techniques, α adrenergic receptors could be distinguished pharmacologically based on their affinities for the antagonists prazosin or yohimbine (Stark, 1981). Definitive evidence for adrenergic receptor subtypes, however, awaited purification and molecular cloning of adrenergic receptor subtypes. In 1986, the genes for the hamster β_2 (Dickson et al., 1986) and turkey β_1 adrenergic receptors (Yarden et al., 1986) were cloned and sequenced. Hydropathy analysis revealed that these proteins contain 7 hydrophobic domains similar to rhodopsin, the receptor for light. Since that time the adrenergic receptor family has expanded to include 3 subtypes of β receptors (Emorine et al., 1989), 3 subtypes of α_1 receptors (Schwinn et al., 1990), and 3 distinct types of α_2 receptors (Lomasney et al., 1990).

The α_2 receptors appear to have diverged rather early from either β or α_1 receptors. The α_2 receptors have been broken down into 3 molecularly distinct subtypes termed α_2C2, α_2C4, and α_2C10 based on their chromosomal location. These subtypes appear to correspond to the pharmacologically

defined α_{2B}, α_{2C}, and α_{2A} subtypes, respectively (Bylund et al., 1992). While all the receptors of the adrenergic type are recognized by epinephrine, they are pharmacologically distinct and are encoded by separate genes. These receptors are generally coupled to different second messenger pathways that are linked through G-proteins. Among the adrenergic receptors, β_1 and β_2 receptors activate the adenylate cyclase, α_2 receptors inhibit adenylate cyclase and α_1 receptors activate phospholipase C pathways, stimulating breakdown of polyphosphoinositides (Chung, F.Z. et al., J. Biol. Chem., 263:4052 (1988)). α_1 and α_2 adrenergic receptors differ in their cell activity for drugs.

In accordance with one aspect of the present invention, there are provided novel polypeptides which have been putatively identified as adrenergic receptors, as well as fragments, analogs and derivatives thereof. The polypeptides of the present invention are of human origin.

In accordance with another aspect of the present invention, there are provided polynucleotides (DNA or RNA) which encode such polypeptides.

In accordance with a further aspect of the present invention, there is provided a process for producing such polypeptides by recombinant techniques.

In accordance with yet a further aspect of the present invention, there are provided antibodies against such polypeptides.

In accordance with another embodiment, there is provided a process for using the receptor to screen for receptor antagonists and/or agonists and/or receptor ligands.

In accordance with still another embodiment of the present invention there is provided a process of using such agonists for therapeutic purposes, for example, to treat upper respiratory conditions.

In accordance with another aspect of the present invention there is provided a process of using such antagonists for treating hypertension.

These and other aspects of the present invention should be apparent to those skilled in the art from the teachings herein.

The following drawings are illustrative of embodiments of the invention and are not meant to limit the scope of the invention as encompassed by the claims.

Figure 1 shows the cDNA sequence and the corresponding deduced amino acid sequence of the G-protein coupled receptor of the present invention. The standard one-letter abbreviation for amino acids is used.

Figure 2 is an illustration of the secondary structural features of the G-protein coupled receptor. The first 7 illustrations set forth the regions of the amino acid sequence which are alpha helices, beta helices, turn regions or coiled regions. The boxed areas are the areas which correspond to the region indicated. The second set of figures illustrate areas of the amino acid sequence which are exposed to intracellular, cytoplasmic or are membrane-spanning. The hydrophilicity part illustrates areas of the protein sequence which are the lipid bilayer of the membrane and are, therefore, hydrophobic, and areas outside the lipid bilayer membrane which are hydrophilic. The antigenic index corresponds to the hydrophilicity plot, since antigenic areas are areas outside the lipid bilayer membrane and are capable of binding antigens. The surface probability plot further corresponds to the antigenic index and the hydrophilicity plot. The amphipathic plots show those regions of the protein sequences which are polar and non-polar.

Figure 3 illustrates an amino acid alignment of the G-protein coupled receptor of the present invention and adrenergic receptors from various species of animals. Faded

areas are those areas which match with the other amino acid sequences in the figure.

It should be pointed out that sequencing inaccuracies are a common problem which occurs in polynucleotide sequences. Accordingly, the sequence of the drawing is based on several sequencing runs and the sequencing accuracy is considered to be at least 97%.

In accordance with an aspect of the present invention, there is provided an isolated nucleic acid (polynucleotide) which encodes for the mature polypeptide having the deduced amino acid sequence of Figure 1 or for the mature polypeptide encoded by the cDNA of the clone deposited as ATCC Deposit No. 75822 on June 24, 1994.

A polynucleotide encoding a polypeptide of the present invention may be found in the brain, lung, pancreas and kidney. The polynucleotide of this invention was discovered in a cDNA library derived from a human infant brain. It is structurally related to the α1 adrenergic receptor family. It contains an open reading frame encoding a protein of 529 amino acid residues. The protein exhibits the highest degree of homology to α_{1c} at the nucleotide sequence level and α_{1B} at the amino acid level with 30 % identity and 47 % similarity over a 500 amino acid stretch.

The polynucleotide of the present invention may be in the form of RNA or in the form of DNA, which DNA includes cDNA, genomic DNA, and synthetic DNA. The DNA may be double-stranded or single-stranded, and if single stranded may be the coding strand or non-coding (anti-sense) strand. The coding sequence which encodes the mature polypeptide may be identical to the coding sequence shown in Figure 1 or that of the deposited clone or may be a different coding sequence which coding sequence, as a result of the redundancy or degeneracy of the genetic code, encodes the same mature polypeptide as the DNA of Figure 1 or the deposited cDNA.

The polynucleotide which encodes for the mature polypeptide of Figure 1 or for the mature polypeptide encoded by the deposited cDNA may include: only the coding sequence for the mature polypeptide; the coding sequence for the mature polypeptide and additional coding sequence such as a leader or secretory sequence or a proprotein sequence; the coding sequence for the mature polypeptide (and optionally additional coding sequence) and non-coding sequence, such as introns or non-coding sequence 5' and/or 3' of the coding sequence for the mature polypeptide.

Thus, the term "polynucleotide encoding a polypeptide" encompasses a polynucleotide which includes only coding sequence for the polypeptide as well as a polynucleotide which includes additional coding and/or non-coding sequence.

The present invention further relates to variants of the hereinabove described polynucleotides which encode for fragments, analogs and derivatives of the polypeptide having the deduced amino acid sequence of Figure 1 or the polypeptide encoded by the cDNA of the deposited clone. The variant of the polynucleotide may be a naturally occurring allelic variant of the polynucleotide or a non-naturally occurring variant of the polynucleotide.

Thus, the present invention includes polynucleotides encoding the same mature polypeptide as shown in Figure 1 or the same mature polypeptide encoded by the cDNA of the deposited clone as well as variants of such polynucleotides which variants encode for a fragment, derivative or analog of the polypeptide of Figure 1 or the polypeptide encoded by the cDNA of the deposited clone. Such nucleotide variants include deletion variants, substitution variants and addition or insertion variants.

As hereinabove indicated, the polynucleotide may have a coding sequence which is a naturally occurring allelic variant of the coding sequence shown in Figure 1 or of the coding sequence of the deposited clone. As known in the art,

an allelic variant is an alternate form of a polynucleotide sequence which may have a substitution, deletion or addition of one or more nucleotides, which does not substantially alter the function of the encoded polypeptide.

The present invention also includes polynucleotides, wherein the coding sequence for the mature polypeptide may be fused in the same reading frame to a polynucleotide sequence which aids in expression and secretion of a polypeptide from a host cell, for example, a leader sequence which functions as a secretory sequence for controlling transport of a polypeptide from the cell. The polypeptide having a leader sequence is a preprotein and may have the leader sequence cleaved by the host cell to form the mature form of the polypeptide. The polynucleotides may also encode for a proprotein which is the mature protein plus additional 5' amino acid residues. A mature protein having a prosequence is a proprotein and is an inactive form of the protein. Once the prosequence is cleaved an active mature protein remains.

Thus, for example, the polynucleotide of the present invention may encode for a mature protein, or for a protein having a prosequence or for a protein having both a prosequence and a presequence (leader sequence).

The polynucleotides of the present invention may also have the coding sequence fused in frame to a marker sequence which allows for purification of the polypeptide of the present invention. The marker sequence may be a hexa-histidine tag supplied by a pQE-9 vector to provide for purification of the mature polypeptide fused to the marker in the case of a bacterial host, or, for example, the marker sequence may be a hemagglutinin (HA) tag when a mammalian host, e.g. COS-7 cells, is used. The HA tag corresponds to an epitope derived from the influenza hemagglutinin protein (Wilson, I., et al., Cell, 37:767 (1984)).

The present invention further relates to polynucleotides which hybridize to the hereinabove-described sequences if there is at least 50% and preferably 70% identity between the sequences. The present invention particularly relates to polynucleotides which hybridize under stringent conditions to the hereinabove-described polynucleotides . As herein used, the term "stringent conditions" means hybridization will occur only if there is at least 95% and preferably at least 97% identity between the sequences. The polynucleotides which hybridize to the hereinabove described polynucleotides in a preferred embodiment encode polypeptides which either retain substantially the same biological function or activity as the mature polypeptide encoded by the cDNA of Figure 1 or the deposited cDNA, i.e. function as a G-protein coupled receptor or retain the ability to bind the ligand for the receptor even though the polypeptide does not function as a G-protein coupled receptor, for example, a soluble form of the receptor.

The deposit(s) referred to herein will be maintained under the terms of the Budapest Treaty on the International Recognition of the Deposit of Micro-organisms for purposes of Patent Procedure. These deposits are provided merely as convenience to those of skill in the art and are not an admission that a deposit is required under 35 U.S.C. §112. The sequence of the polynucleotides contained in the deposited materials, as well as the amino acid sequence of the polypeptides encoded thereby, are incorporated herein by reference and are controlling in the event of any conflict with any description of sequences herein. A license may be required to make, use or sell the deposited materials, and no such license is hereby granted.

The present invention further relates to a G-protein coupled receptor polypeptide which has the deduced amino acid sequence of Figure 1 or which has the amino acid sequence

encoded by the deposited cDNA, as well as fragments, analogs and derivatives of such polypeptide.

The terms "fragment," "derivative" and "analog" when referring to the polypeptide of Figure 1 or that encoded by the deposited cDNA, means a polypeptide which either retains substantially the same biological function or activity as such polypeptide, i.e. functions as a G-protein coupled receptor, or retains the ability to bind the ligand or the receptor even though the polypeptide does not function as a G-protein coupled receptor, for example, a soluble form of the receptor. An analog includes a proprotein which can be activated by cleavage of the proprotein portion to produce an active mature polypeptide.

The polypeptide of the present invention may be a recombinant polypeptide, a natural polypeptide or a synthetic polypeptide, preferably a recombinant polypeptide.

The fragment, derivative or analog of the polypeptide of Figure 1 or that encoded by the deposited cDNA may be (i) one in which one or more of the amino acid residues are substituted with a conserved or non-conserved amino acid residue (preferably a conserved amino acid residue) and such substituted amino acid residue may or may not be one encoded by the genetic code, or (ii) one in which one or more of the amino acid residues includes a substituent group, or (iii) one in which the mature polypeptide is fused with another compound, such as a compound to increase the half-life of the polypeptide (for example, polyethylene glycol), or (iv) one in which the additional amino acids are fused to the mature polypeptide, such as a leader or secretory sequence or a sequence which is employed for purification of the mature polypeptide or a proprotein sequence. Such fragments, derivatives and analogs are deemed to be within the scope of those skilled in the art from the teachings herein.

The polypeptides and polynucleotides of the present invention are preferably provided in an isolated form, and preferably are purified to homogeneity.

The term "isolated" means that the material is removed from its original environment (e.g., the natural environment if it is naturally occurring). For example, a naturally-occurring polynucleotide or polypeptide present in a living animal is not isolated, but the same polynucleotide or polypeptide, separated from some or all of the coexisting materials in the natural system, is isolated. Such polynucleotides could be part of a vector and/or such polynucleotides or polypeptides could be part of a composition, and still be isolated in that such vector or composition is not part of its natural environment.

The present invention also relates to vectors which include polynucleotides of the present invention, host cells which are genetically engineered with vectors of the invention and the production of polypeptides of the invention by recombinant techniques.

Host cells are genetically engineered (transduced or transformed or transfected) with the vectors of this invention which may be, for example, a cloning vector or an expression vector. The vector may be, for example, in the form of a plasmid, a viral particle, a phage, etc. The engineered host cells can be cultured in conventional nutrient media modified as appropriate for activating promoters, selecting transformants or amplifying the adrenergic receptor genes. The culture conditions, such as temperature, pH and the like, are those previously used with the host cell selected for expression, and will be apparent to the ordinarily skilled artisan.

The polynucleotides of the present invention may be employed for producing polypeptides by recombinant techniques. Thus, for example, the polynucleotide may be included in any one of a variety of expression vectors for

expressing a polypeptide. Such vectors include chromosomal, nonchromosomal and synthetic DNA sequences, e.g., derivatives of SV40; bacterial plasmids; phage DNA; baculovirus; yeast plasmids; vectors derived from combinations of plasmids and phage DNA, viral DNA such as vaccinia, adenovirus, fowl pox virus, and pseudorabies. However, any other vector may be used as long as it is replicable and viable in the host.

The appropriate DNA sequence may be inserted into the vector by a variety of procedures. In general, the DNA sequence is inserted into an appropriate restriction endonuclease site(s) by procedures known in the art. Such procedures and others are deemed to be within the scope of those skilled in the art.

The DNA sequence in the expression vector is operatively linked to an appropriate expression control sequence(s) (promoter) to direct mRNA synthesis. As representative examples of such promoters, there may be mentioned: LTR or SV40 promoter, the E. coli. lac or trp, the phage lambda P_L promoter and other promoters known to control expression of genes in prokaryotic or eukaryotic cells or their viruses. The expression vector also contains a ribosome binding site for translation initiation and a transcription terminator. The vector may also include appropriate sequences for amplifying expression.

In addition, the expression vectors preferably contain one or more selectable marker genes to provide a phenotypic trait for selection of transformed host cells such as dihydrofolate reductase or neomycin resistance for eukaryotic cell culture, or such as tetracycline or ampicillin resistance in E. coli.

The vector containing the appropriate DNA sequence as hereinabove described, as well as an appropriate promoter or control sequence, may be employed to transform an appropriate host to permit the host to express the protein.

As representative examples of appropriate hosts, there may be mentioned: bacterial cells, such as E. coli, Streptomyces, Salmonella typhimurium; fungal cells, such as yeast; insect cells such as Drosophila and Sf9; animal cells such as CHO, COS or Bowes melanoma; plant cells, etc. The selection of an appropriate host is deemed to be within the scope of those skilled in the art from the teachings herein.

More particularly, the present invention also includes recombinant constructs comprising one or more of the sequences as broadly described above. The constructs comprise a vector, such as a plasmid or viral vector, into which a sequence of the invention has been inserted, in a forward or reverse orientation. In a preferred aspect of this embodiment, the construct further comprises regulatory sequences, including, for example, a promoter, operably linked to the sequence. Large numbers of suitable vectors and promoters are known to those of skill in the art, and are commercially available. The following vectors are provided by way of example. Bacterial: pQE70, pQE60, pQE-9 (Qiagen), pbs, pD10, phagescript, psiX174, pbluescript SK, pbsks, pNH8A, pNH16a, pNH18A, pNH46A (Stratagene); ptrc99a, pKK223-3, pKK233-3, pDR540, pRIT5 (Pharmacia). Eukaryotic: pWLNEO, pSV2CAT, pOG44, pXT1, pSG (Stratagene) pSVK3, pBPV, pMSG, pSVL (Pharmacia). However, any other plasmid or vector may be used as long as they are replicable and viable in the host.

Promoter regions can be selected from any desired gene using CAT (chloramphenicol transferase) vectors or other vectors with selectable markers. Two appropriate vectors are PKK232-8 and PCM7. Particular named bacterial promoters include lacI, lacZ, T3, T7, gpt, lambda P_R, P_L and trp. Eukaryotic promoters include CMV immediate early, HSV thymidine kinase, early and late SV40, LTRs from retrovirus, and mouse metallothionein-I. Selection of the appropriate

vector and promoter is well within the level of ordinary skill in the art.

In a further embodiment, the present invention relates to host cells containing the above-described constructs. The host cell can be a higher eukaryotic cell, such as a mammalian cell, or a lower eukaryotic cell, such as a yeast cell, or the host cell can be a prokaryotic cell, such as a bacterial cell. Introduction of the construct into the host cell can be effected by calcium phosphate transfection, DEAE-Dextran mediated transfection, or electroporation. (Davis, L., Dibner, M., Battey, I., Basic Methods in Molecular Biology, (1986)).

The constructs in host cells can be used in a conventional manner to produce the gene product encoded by the recombinant sequence. Alternatively, the polypeptides of the invention can be synthetically produced by conventional peptide synthesizers.

Mature proteins can be expressed in mammalian cells, yeast, bacteria, or other cells under the control of appropriate promoters. Cell-free translation systems can also be employed to produce such proteins using RNAs derived from the DNA constructs of the present invention. Appropriate cloning and expression vectors for use with prokaryotic and eukaryotic hosts are described by Sambrook, et al., Molecular Cloning: A Laboratory Manual, Second Edition, Cold Spring Harbor, N.Y., (1989), the disclosure of which is hereby incorporated by reference.

Transcription of the DNA encoding the polypeptides of the present invention by higher eukaryotes is increased by inserting an enhancer sequence into the vector. Enhancers are cis-acting elements of DNA, usually about from 10 to 300 bp that act on a promoter to increase its transcription. Examples including the SV40 enhancer on the late side of the replication origin bp 100 to 270, a cytomegalovirus early

promoter enhancer, the polyoma enhancer on the late side of the replication origin, and adenovirus enhancers.

Generally, recombinant expression vectors will include origins of replication and selectable markers permitting transformation of the host cell, e.g., the ampicillin resistance gene of E. coli and S. cerevisiae TRP1 gene, and a promoter derived from a highly-expressed gene to direct transcription of a downstream structural sequence. Such promoters can be derived from operons encoding glycolytic enzymes such as 3-phosphoglycerate kinase (PGK), α-factor, acid phosphatase, or heat shock proteins, among others. The heterologous structural sequence is assembled in appropriate phase with translation initiation and termination sequences, and preferably, a leader sequence capable of directing secretion of translated protein into the periplasmic space or extracellular medium. Optionally, the heterologous sequence can encode a fusion protein including an N-terminal identification peptide imparting desired characteristics, e.g., stabilization or simplified purification of expressed recombinant product.

Useful expression vectors for bacterial use are constructed by inserting a structural DNA sequence encoding a desired protein together with suitable translation initiation and termination signals in operable reading phase with a functional promoter. The vector will comprise one or more phenotypic selectable markers and an origin of replication to ensure maintenance of the vector and to, if desirable, provide amplification within the host. Suitable prokaryotic hosts for transformation include E. coli, Bacillus subtilis, Salmonella typhimurium and various species within the genera Pseudomonas, Streptomyces, and Staphylococcus, although others may also be employed as a matter of choice.

As a representative but nonlimiting example, useful expression vectors for bacterial use can comprise a

selectable marker and bacterial origin of replication derived from commercially available plasmids comprising genetic elements of the well known cloning vector pBR322 (ATCC 37017). Such commercial vectors include, for example, pKK223-3 (Pharmacia Fine Chemicals, Uppsala, Sweden) and GEM1 (Promega Biotec, Madison, WI, USA). These pBR322 "backbone" sections are combined with an appropriate promoter and the structural sequence to be expressed.

Following transformation of a suitable host strain and growth of the host strain to an appropriate cell density, the selected promoter is induced by appropriate means (e.g., temperature shift or chemical induction) and cells are cultured for an additional period.

Cells are typically harvested by centrifugation, disrupted by physical or chemical means, and the resulting crude extract retained for further purification.

Microbial cells employed in expression of proteins can be disrupted by any convenient method, including freeze-thaw cycling, sonication, mechanical disruption, or use of cell lysing agents, such methods are well know to those skilled in the art.

Various mammalian cell culture systems can also be employed to express recombinant protein. Examples of mammalian expression systems include the COS-7 lines of monkey kidney fibroblasts, described by Gluzman, Cell, 23:175 (1981), and other cell lines capable of expressing a compatible vector, for example, the C127, 3T3, CHO, HeLa and BHK cell lines. Mammalian expression vectors will comprise an origin of replication, a suitable promoter and enhancer, and also any necessary ribosome binding sites, polyadenylation site, splice donor and acceptor sites, transcriptional termination sequences, and 5' flanking nontranscribed sequences. DNA sequences derived from the SV40 splice, and polyadenylation sites may be used to provide the required nontranscribed genetic elements.

The G-protein coupled receptor polypeptides can be recovered and purified from recombinant cell cultures by methods including ammonium sulfate or ethanol precipitation, acid extraction, anion or cation exchange chromatography, phosphocellulose chromatography, hydrophobic interaction chromatography, affinity chromatography hydroxylapatite chromatography and lectin chromatography. Protein refolding steps can be used, as necessary, in completing configuration of the mature protein. Finally, high performance liquid chromatography (HPLC) can be employed for final purification steps.

The polypeptides of the present invention may be a naturally purified product, or a product of chemical synthetic procedures, or produced by recombinant techniques from a prokaryotic or eukaryotic host (for example, by bacterial, yeast, higher plant, insect and mammalian cells in culture). Depending upon the host employed in a recombinant production procedure, the polypeptides of the present invention may be glycosylated or may be non-glycosylated. Polypeptides of the invention may also include an initial methionine amino acid residue.

The G-protein coupled receptor of the present invention may be employed in a process for screening for antagonists and/or agonists for the receptor.

In general, such screening procedures involve providing appropriate cells which express the receptor on the surface thereof. In particular, a polynucleotide encoding the receptor of the present invention is employed to transfect cells to thereby express the G-protein coupled receptor. Such transfection may be accomplished by procedures as hereinabove described.

One such screening procedure involves the use of the melanophores which are transfected to express the G-protein coupled receptor of the present invention. Such a screening

technique is described in PCT WO 92/01810 published February 6, 1992.

Thus, for example, such assay may be employed for screening for a receptor antagonist by contacting the melanophore cells which encode the G-protein coupled receptor with both the receptor ligand and a compound to be screened. Inhibition of the signal generated by the ligand indicates that a compound is a potential antagonist for the receptor, i.e., inhibits activation of the receptor.

The screen may be employed for determining an agonist by contacting such cells with compounds to be screened and determining whether such compound generates a signal, i.e., activates the receptor.

Other screening techniques include the use of cells which express the G-protein coupled receptor (for example, transfected CHO cells) in a system which measures extracellular pH changes caused by receptor activation, for example, as described in Science, volume 246, pages 181-296 (October 1989). For example, potential agonists or antagonists may be contacted with a cell which expresses the G-protein coupled receptor and a second messenger response, e.g. signal transduction or pH changes, may be measured to determine whether the potential agonist or antagonist is effective.

Another such screening technique involves introducing RNA encoding the G-protein coupled receptor into xenopus oocytes to transiently express the receptor. The receptor oocytes may then be contacted in the case of antagonist screening with the receptor ligand and a compound to be screened, followed by detection of inhibition of a calcium signal.

Another screening technique involves expressing the G-protein coupled receptor in which the receptor is linked to a phospholipase C or D. As representative examples of such cells, there may be mentioned endothelial cells, smooth

muscle cells, embryonic kidney cells, etc. The screening for an antagonist or agonist may be accomplished as hereinabove described by detecting activation of the receptor or inhibition of activation of the receptor from the phospholipase second signal.

Another method involves screening for antagonists by determining inhibition of binding of labeled ligand to cells which have the receptor on the surface thereof. Such a method involves transfecting a eukaryotic cell with DNA encoding the G-protein coupled receptor such that the cell expresses the receptor on its surface and contacting the cell with a potential antagonist in the presence of a labeled form of a known ligand. The ligand can be labeled, e.g., by radioactivity. The amount of labeled ligand bound to the receptors is measured, e.g., by measuring radioactivity of the receptors. If the potential antagonist binds to the receptor as determined by a reduction of labeled ligand which binds to the receptors, the binding of labeled ligand to the receptor is inhibited.

The present invention also provides a method for determining whether a ligand not known to be capable of binding to a G-protein coupled receptor can bind to such receptor which comprises contacting a mammalian cell which expresses a G-protein coupled receptor with the ligand under conditions permitting binding of ligands to the G-protein coupled receptor, detecting the presence of a ligand which binds to the receptor and thereby determining whether the ligand binds to the G-protein coupled receptor. The systems hereinabove described for determining agonists and/or antagonists may also be employed for determining ligands which bind to the receptor.

In general, antagonists for G-protein coupled receptors which are determined by screening procedures may be employed for a variety of therapeutic purposes. For example, such antagonists have been employed for treatment of hypertension,

angina pectoris, myocardial infarction, ulcers, asthma, allergies, psychoses, depression, migraine, vomiting, and benign prostatic hypertrophy.

Agonists for G-protein coupled receptors are also useful for therapeutic purposes, such as the treatment of asthma, Parkinson's disease, acute heart failure, hypotension, urinary retention, and osteoporosis.

A potential antagonist is an antibody, or in some cases an oligonucleotide, which binds to the G-protein coupled receptor but does not elicit a second messenger response such that the activity of the G-protein coupled receptor is prevented. Potential antagonists also include proteins which are closely related to the ligand of the G-protein coupled receptor, i.e. a fragment of the ligand, which have lost biological function and when binding to the G-protein coupled receptor, elicit no response.

A potential antagonist also includes an antisense construct prepared through the use of antisense technology. Antisense technology can be used to control gene expression through triple-helix formation or antisense DNA or RNA, both of which methods are based on binding of a polynucleotide to DNA or RNA. For example, the 5' coding portion of the polynucleotide sequence, which encodes for the mature polypeptides of the present invention, is used to design an antisense RNA oligonucleotide of from about 10 to 40 base pairs in length. A DNA oligonucleotide is designed to be complementary to a region of the gene involved in transcription (triple helix -see Lee et al., Nucl. Acids Res., 6:3073 (1979); Cooney et al, Science, 241:456 (1988); and Dervan et al., Science, 251: 1360 (1991)), thereby preventing transcription and the production of G-protein coupled receptors. The antisense RNA oligonucleotide hybridizes to the mRNA *in vivo* and blocks translation of the mRNA molecule into the G-protein coupled receptors (antisense - Okano, J. Neurochem., 56:560 (1991); Oligodeoxynucleotides

as Antisense Inhibitors of Gene Expression, CRC Press, Boca Raton, FL (1988)). The oligonucleotides described above can also be delivered to cells such that the antisense RNA or DNA may be expressed *in vivo* to inhibit production of G-protein coupled receptors.

Another potential antagonist is a small molecule which binds to the G-protein coupled receptor, making it inaccessible to ligands such that normal biological activity is prevented. Examples of small molecules include but are not limited to small peptides or peptide-like molecules.

Potential antagonists also include a soluble form of a G-protein coupled receptor, e.g. a fragment of the receptor, which binds to the ligand and prevents the ligand from interacting with membrane bound G-protein coupled receptors.

The G-protein coupled receptor of the present invention has been putatively identified as an adrenergic receptor. This identification has been made as a result of amino acid sequence homology.

The antagonists may be used to treat hypertension by controlling β-adrenergic receptors from stimulating cardiac contractility and lowering heart rate. The antagonists may also be used to prevent vasoconstriction controlled by α-adrenergic receptors. The antagonists may be employed in a composition with a pharmaceutically acceptable carrier, e.g., as hereinafter described.

The agonists identified by the screening method as described above, may be employed to stimulate the α-adrenergic receptor for the treatment of upper respiratory conditions, e.g. allergic rhinitis, hay fever, acute coryza and sinusitis. Stimulating the α-adrenergic receptors constricts the nasal mucosal blood vessels, lessening secretions, and edema. α-adrenergic receptors also control pupil dilation and uterine inhibition, therefore, the agonists may also be used to stimulate those actions.

β-Adrenergic receptors mediate vasorelaxation. Stimulating β-adrenergic receptors by the administration of an agonist may be used to treat bronchial asthma by causing bronchial smooth muscle relaxation and modulating mediator release, at least in part by stimulating the adenylate cyclase-cAMP system. Stimulating β-adrenergic receptors and consequent vasorelaxation may also be used to treat coronary artery disease, atherosclerosis and arteriosclerosis.

The adrenergic receptor and antagonists or agonists may be employed in combination with a suitable pharmaceutical carrier. Such compositions comprise a therapeutically effective amount of the polypeptide, and a pharmaceutically acceptable carrier or excipient. Such a carrier includes but is not limited to saline, buffered saline, dextrose, water, glycerol, ethanol, and combinations thereof. The formulation should suit the mode of administration.

The invention also provides a pharmaceutical pack or kit comprising one or more containers filled with one or more of the ingredients of the pharmaceutical compositions of the invention. Associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration. In addition, the polypeptides of the present invention may be employed in conjunction with other therapeutic compounds.

The pharmaceutical compositions may be administered in a convenient manner such as by the topical, intravenous, intraperitoneal, intramuscular, subcutaneous, intranasal or intradermal routes. The pharmaceutical compositions are administered in an amount which is effective for treating and/or prophylaxis of the specific indication. In general, the pharmaceutical compositions will be administered in an amount of at least about 10 μg/kg body weight and in most cases they will be administered in an amount not in excess of

about 8 mg/Kg body weight per day. In most cases, the dosage is from about 10 μg/kg to about 1 mg/kg body weight daily, taking into account the routes of administration, symptoms, etc.

The adrenergic receptor polypeptides and antagonists or agonists which are polypeptides, may be employed in accordance with the present invention by expression of such polypeptides *in vivo*, which is often referred to as "gene therapy."

Thus, for example, cells from a patient may be engineered with a polynucleotide (DNA or RNA) encoding a polypeptide *ex vivo*, with the engineered cells then being provided to a patient to be treated with the polypeptide. Such methods are well-known in the art. For example, cells may be engineered by procedures known in the art by use of a retroviral particle containing RNA encoding a polypeptide of the present invention.

Similarly, cells may be engineered *in vivo* for expression of a polypeptide *in vivo* by, for example, procedures known in the art. As known in the art, a producer cell for producing a retroviral particle containing RNA encoding the polypeptide of the present invention may be administered to a patient for engineering cells *in vivo* and expression of the polypeptide *in vivo*. These and other methods for administering a polypeptide of the present invention by such method should be apparent to those skilled in the art from the teachings of the present invention. For example, the expression vehicle for engineering cells may be other than a retrovirus, for example, an adenovirus which may be used to engineer cells in vivo after combination with a suitable delivery vehicle.

The sequences of the present invention are also valuable for chromosome identification. The sequence is specifically targeted to and can hybridize with a particular location on an individual human chromosome. Moreover, there is a current

need for identifying particular sites on the chromosome. Few chromosome marking reagents based on actual sequence data (repeat polymorphisms) are presently available for marking chromosomal location. The mapping of DNAs to chromosomes according to the present invention is an important first step in correlating those sequences with genes associated with disease.

Briefly, sequences can be mapped to chromosomes by preparing PCR primers (preferably 15-25 bp) from the cDNA. Computer analysis of the cDNA is used to rapidly select primers that do not span more than one exon in the genomic DNA, thus complicating the amplification process. These primers are then used for PCR screening of somatic cell hybrids containing individual human chromosomes. Only those hybrids containing the human gene corresponding to the primer will yield an amplified fragment.

PCR mapping of somatic cell hybrids is a rapid procedure for assigning a particular DNA to a particular chromosome. Using the present invention with the same oligonucleotide primers, sublocalization can be achieved with panels of fragments from specific chromosomes or pools of large genomic clones in an analogous manner. Other mapping strategies that can similarly be used to map to its chromosome include *in situ* hybridization, prescreening with labeled flow-sorted chromosomes and preselection by hybridization to construct chromosome specific-cDNA libraries.

Fluorescence *in situ* hybridization (FISH) of a cDNA clone to a metaphase chromosomal spread can be used to provide a precise chromosomal location in one step. This technique can be used with cDNA as short as 500 or 600 bases; however, clones larger than 2,000 bp have a higher likelihood of binding to a unique chromosomal location with sufficient signal intensity for simple detection. FISH requires use of the clones from which the EST was derived, and the longer the better. For example, 2,000 bp is good, 4,000 is better, and

more than 4,000 is probably not necessary to get good results a reasonable percentage of the time. For a review of this technique, see Verma et al., Human Chromosomes: a Manual of Basic Techniques, Pergamon Press, New York (1988).

Once a sequence has been mapped to a precise chromosomal location, the physical position of the sequence on the chromosome can be correlated with genetic map data. Such data are found, for example, in V. McKusick, Mendelian Inheritance in Man (available on line through Johns Hopkins University Welch Medical Library). The relationship between genes and diseases that have been mapped to the same chromosomal region are then identified through linkage analysis (coinheritance of physically adjacent genes).

Next, it is necessary to determine the differences in the cDNA or genomic sequence between affected and unaffected individuals. If a mutation is observed in some or all of the affected individuals but not in any normal individuals, then the mutation is likely to be the causative agent of the disease.

With current resolution of physical mapping and genetic mapping techniques, a cDNA precisely localized to a chromosomal region associated with the disease could be one of between 50 and 500 potential causative genes. (This assumes 1 megabase mapping resolution and one gene per 20 kb).

The polypeptides, their fragments or other derivatives, or analogs thereof, or cells expressing them can be used as an immunogen to produce antibodies thereto. These antibodies can be, for example, polyclonal or monoclonal antibodies. The present invention also includes chimeric, single chain, and humanized antibodies, as well as Fab fragments, or the product of an Fab expression library. Various procedures known in the art may be used for the production of such antibodies and fragments.

Antibodies generated against the polypeptides corresponding to a sequence of the present invention can be obtained by direct injection of the polypeptides into an animal or by administering the polypeptides to an animal, preferably a nonhuman. The antibody so obtained will then bind the polypeptides itself. In this manner, even a sequence encoding only a fragment of the polypeptides can be used to generate antibodies binding the whole native polypeptides. Such antibodies can then be used to isolate the polypeptide from tissue expressing that polypeptide.

For preparation of monoclonal antibodies, any technique which provides antibodies produced by continuous cell line cultures can be used. Examples include the hybridoma technique (Kohler and Milstein, 1975, Nature, 256:495-497), the trioma technique, the human B-cell hybridoma technique (Kozbor et al., 1983, Immunology Today 4:72), and the EBV-hybridoma technique to produce human monoclonal antibodies (Cole, et al., 1985, in Monoclonal Antibodies and Cancer Therapy, Alan R. Liss, Inc., pp. 77-96).

Techniques described for the production of single chain antibodies (U.S. Patent 4,946,778) can be adapted to produce single chain antibodies to immunogenic polypeptide products of this invention.

The present invention will be further described with reference to the following examples; however, it is to be understood that the present invention is not limited to such examples. All parts or amounts, unless otherwise specified, are by weight.

In order to facilitate understanding of the following examples certain frequently occurring methods and/or terms will be described.

"Plasmids" are designated by a lower case p preceded and/or followed by capital letters and/or numbers. The starting plasmids herein are either commercially available, publicly available on an unrestricted basis, or can be

constructed from available plasmids in accord with published procedures. In addition, equivalent plasmids to those described are known in the art and will be apparent to the ordinarily skilled artisan.

"Digestion" of DNA refers to catalytic cleavage of the DNA with a restriction enzyme that acts only at certain sequences in the DNA. The various restriction enzymes used herein are commercially available and their reaction conditions, cofactors and other requirements were used as would be known to the ordinarily skilled artisan. For analytical purposes, typically 1 μg of plasmid or DNA fragment is used with about 2 units of enzyme in about 20 μl of buffer solution. For the purpose of isolating DNA fragments for plasmid construction, typically 5 to 50 μg of DNA are digested with 20 to 250 units of enzyme in a larger volume. Appropriate buffers and substrate amounts for particular restriction enzymes are specified by the manufacturer. Incubation times of about 1 hour at 37°C are ordinarily used, but may vary in accordance with the supplier's instructions.

"Oligonucleotides" refers to either a single stranded polydeoxynucleotide or two complementary polydeoxynucleotide strands which may be chemically synthesized. Such synthetic oligonucleotides have no 5' phosphate and thus will not ligate to another oligonucleotide without adding a phosphate with an ATP in the presence of a kinase. A synthetic oligonucleotide will ligate to a fragment that has not been dephosphorylated.

"Ligation" refers to the process of forming phosphodiester bonds between two double stranded nucleic acid fragments (Maniatis, T., et al., Id., p. 146). Unless otherwise provided, ligation may be accomplished using known buffers and conditions with 10 units of T4 DNA ligase ("ligase") per 0.5 μg of approximately equimolar amounts of the DNA fragments to be ligated.

Unless otherwise stated, transformation was performed as described in the method of Graham, F. and Van der Eb, A., Virology, 52:456-457 (1973).

Example 1

Bacterial Expression and Purification of adrenergic receptor

The DNA sequence encoding the adrenergic receptor, ATCC # 75822, is initially amplified using PCR oligonucleotide primers corresponding to the 5' and 3' sequences of the processed protein (minus the signal peptide sequence) and the vector sequences 3' to the adrenergic receptor gene. Additional nucleotides corresponding to the adrenergic receptor coding sequence were added to the 5' and 3' sequences respectively. The 5' oligonucleotide primer has the sequence 5' CCCACCCCACGCCGAGGTGCA GGTGCA**GGATCC**ATGAGCCTCAAC 3' contains a BamHI restriction enzyme site (bold) followed by 9 nucleotides of the adrenergic receptor coding sequence starting from the presumed terminal amino acid of the processed protein codon. The 3' sequence 5' CAGCCCCACGGCACCC**TCTAGA**CCTCATCTCTGCTCGGCAGCT 3' contains complementary sequences to an XbaI site and is followed by 21 nucleotides of the adrenergic receptor coding sequence. The restriction enzyme sites correspond to the restriction enzyme sites on the bacterial expression vector pQE-9 (Qiagen, Inc. 9259 Eton Avenue, Chatsworth, CA, 91311). pQE-9 encodes antibiotic resistance (Amp'), a bacterial origin of replication (ori), an IPTG-regulatable promoter operator (P/O), a ribosome binding site (RBS), a 6-His tag and restriction enzyme sites. pQE-9 was then digested with BamHI and XbaI. The amplified sequences were ligated into pQE-9 and were inserted in frame with the sequence encoding for the histidine tag and the RBS. The ligation mixture was then used to transform E. coli strain available from Qiagen under the trademark M15/rep 4 by the procedure described in

Sambrook, J. et al., Molecular Cloning: A Laboratory Manual, Cold Spring Laboratory Press, (1989). M15/rep4 contains multiple copies of the plasmid pREP4, which expresses the lacI repressor and also confers kanamycin resistance (Kan^r). Transformants are identified by their ability to grow on LB plates and ampicillin/kanamycin resistant colonies were selected. Plasmid DNA was isolated and confirmed by restriction analysis. Clones containing the desired constructs were grown overnight (O/N) in liquid culture in LB media supplemented with both Amp (100 ug/ml) and Kan (25 ug/ml). The O/N culture is used to inoculate a large culture at a ratio of 1:100 to 1:250. The cells were grown to an optical density 600 (O.D.^{600}) of between 0.4 and 0.6. IPTG ("Isopropyl-B-D-thiogalacto pyranoside") was then added to a final concentration of 1 mM. IPTG induces by inactivating the lacI repressor, clearing the P/O leading to increased gene expression. Cells were grown an extra 3 to 4 hours. Cells were then harvested by centrifugation. The cell pellet was solubilized in the chaotropic agent 6 Molar Guanidine HCl. After clarification, solubilized adrenergic receptor protein was purified from this solution by chromatography on a Nickel-Chelate column under conditions that allow for tight binding by proteins containing the 6-His tag (Hochuli, E. et al., J. Chromatography 411:177-184 (1984)). The adrenergic receptor protein was eluted from the column in 6 molar guanidine HCl pH 5.0 and for the purpose of renaturation adjusted to 3 molar guanidine HCl, 100mM sodium phosphate, 10 mmolar glutathione (reduced) and 2 mmolar glutathione (oxidized). After incubation in this solution for 12 hours the protein was dialyzed to 10 mmolar sodium phosphate.

Example 2

Expression of Recombinant Adrenergic Receptor in COS cells

The expression of plasmid, pAdrenergic Receptor HA is derived from a vector pcDNAI/Amp (Invitrogen) containing: 1)

SV40 origin of replication, 2) ampicillin resistance gene, 3) E.coli replication origin, 4) CMV promoter followed by a polylinker region, a SV40 intron and polyadenylation site. A DNA fragment encoding the entire adrenergic receptor precursor and a HA tag fused in frame to its 3' end was cloned into the polylinker region of the vector, therefore, the recombinant protein expression is directed under the CMV promoter. The HA tag correspond to an epitope derived from the influenza hemagglutinin protein as previously described (I. Wilson, H. Niman, R. Heighten, A Cherenson, M. Connolly, and R. Lerner, 1984, Cell 37, 767). The infusion of HA tag to our target protein allows easy detection of the recombinant protein with an antibody that recognizes the HA epitope.

The plasmid construction strategy is described as follows:

The DNA sequence encoding the adrenergic receptor, ATCC # 75822, was constructed by PCR on the original EST cloned using two primers: the 5' primer 5' CCCACCCCACGCCG**GGATCC**ACTGACCATG 3' contains a BamHI site followed by 10 nucleotides of sequence ending at the initiation codon; the 3' sequence 5' CCGCTCGA GCCTTCAAGCGTAGTCTGGGACGTCGTATGGGTATCTCTGCTCGGCAGC 3' contains complementary sequences to an EcoRI site, translation stop codon, HA tag and the last 21 nucleotides of the adrenergic receptor coding sequence coding sequence (not including the stop codon). Therefore, the PCR product contains a BAmHI site, coding sequence followed by HA tag fused in frame, a translation termination stop codon next to the HA tag, and an EcoRI site. The PCR amplified DNA fragment and the vector, pcDNAI/Amp, were digested with BamHI and EcoRI restriction enzyme and ligated. The ligation mixture was transformed into E. coli strain SURE (available from Stratagene Cloning Systems, 11099 North Torrey Pines Road, La Jolla, CA 92037) the transformed culture was plated on ampicillin media

plates and resistant colonies were selected. Plasmid DNA was isolated from transformants and examined by restriction analysis for the presence of the correct fragment. For expression of the recombinant adrenergic receptor protein, COS cells were transfected with the expression vector by DEAE-DEXTRAN method. (J. Sambrook, E. Fritsch, T. Maniatis, Molecular Cloning: A Laboratory Manual, Cold Spring Laboratory Press, (1989)). The expression of the adrenergic receptor HA protein was detected by radiolabelling and immunoprecipitation method. (E. Harlow, D. Lane, Antibodies: A Laboratory Manual, Cold Spring Harbor Laboratory Press, (1988)). Cells were labelled for 8 hours with ^{35}S-cysteine two days post transfection. Culture media were then collected and cells were lysed with detergent (RIPA buffer (150 mM NaCl, 1% NP-40, 0.1% SDS, 1% NP-40, 0.5% DOC, 50mM Tris, pH 7.5). (Wilson, I. et al., Id. 37:767 (1984)). Both cell lysate and culture media were precipitated with a HA specific monoclonal antibody. Proteins precipitated were analyzed on 15% SDS-PAGE gels.

Example 3

Cloning and expression of adrenergic receptor using the baculovirus expression system

The DNA sequence encoding the full length adrenergic receptor protein, ATCC # 75822, was amplified using PCR oligonucleotide primers corresponding to the 5' and 3' sequences of the gene:

The 5' primer has the sequence 5' CCCACCC CACGCCG**GGATCC**ACTGACCATG 3' and contains a BamHI restriction enzyme site (in bold) followed by 10 nucleotides resembling an efficient signal for the initiation of translation in eukaryotic cells (J. Mol. Biol. 1987, 196, 947-950, Kozak, M.), the initiation codon for translation "ATG" is underlined).

The 3' primer has the sequence 5' CAGCCCCACGGCACCC**TCTAGA**CCTCATCTCTGCTCGGCAGCT 3' and contains the cleavage site for the restriction endonuclease XbaI and 16 nucleotides complementary to the 3' non-translated sequence of the adrenergic receptor gene. The amplified sequences were isolated from a 1% agarose gel using a commercially available kit ("Geneclean," BIO 101 Inc., La Jolla, Ca.). The fragment was then digested with the endonucleases BamHI and XbaI and purified again on a 1% agarose gel. This fragment is designated F2.

The vector pRG1 (modification of pVL941 vector, discussed below) is used for the expression of the adrenergic receptor protein using the baculovirus expression system (for review see: Summers, M.D. and Smith, G.E. 1987, A manual of methods for baculovirus vectors and insect cell culture procedures, Texas Agricultural Experimental Station Bulletin No. 1555). This expression vector contains the strong polyhedrin promoter of the Autographa californica nuclear polyhedrosis virus (AcMNPV) followed by the recognition sites for the restriction endonucleases BamHI and XbaI. The polyadenylation site of the simian virus (SV)40 is used for efficient polyadenylation. For an easy selection of recombinant viruses the beta-galactosidase gene from E.coli is inserted in the same orientation as the polyhedrin promoter followed by the polyadenylation signal of the polyhedrin gene. The polyhedrin sequences are flanked at both sides by viral sequences for the cell-mediated homologous recombination of cotransfected wild-type viral DNA. Many other baculovirus vectors could be used in place of pRG1 such as pAc373, pVL941 and pAcIM1 (Luckow, V.A. and Summers, M.D., Virology, 170:31-39).

The plasmid was digested with the restriction enzymes BamHI and XbaI and then dephosphorylated using calf intestinal phosphatase by procedures known in the art. The

DNA was then isolated from a 1% agarose gel. This vector DNA is designated V2.

Fragment F2 and the dephosphorylated plasmid V2 were ligated with T4 DNA ligase. E.coli XL1Blue cells were then transformed and bacteria identified that contained the plasmid (pBacAdrenergic Receptor) with the adrenergic receptor gene using the enzymes BamHI and XbaI. The sequence of the cloned fragment was confirmed by DNA sequencing.

5 µg of the plasmid pBacAdrenergic receptor were cotransfected with 1.0 µg of a commercially available linearized baculovirus ("BaculoGold™ baculovirus DNA", Pharmingen, San Diego, CA.) using the lipofection method (Felgner et al. Proc. Natl. Acad. Sci. USA, 84:7413-7417 (1987)).

1µg of BaculoGold™ virus DNA and 5 µg of the plasmid pBacAdrenergic Receptor were mixed in a sterile well of a microtiter plate containing 50 µl of serum free Grace's medium (Life Technologies Inc., Gaithersburg, MD). Afterwards 10 µl Lipofectin plus 90 µl Grace's medium were added, mixed and incubated for 15 minutes at room temperature. Then the transfection mixture was added dropwise to the Sf9 insect cells (ATCC CRL 1711) seeded in a 35 mm tissue culture plate with 1ml Grace' medium without serum. The plate was rocked back and forth to mix the newly added solution. The plate was then incubated for 5 hours at 27°C. After 5 hours the transfection solution was removed from the plate and 1 ml of Grace's insect medium supplemented with 10% fetal calf serum was added. The plate was put back into an incubator and cultivation continued at 27°C for four days.

After four days the supernatant was collected and a plaque assay performed similar as described by Summers and Smith (supra). As a modification an agarose gel with "Blue Gal" (Life Technologies Inc., Gaithersburg) was used which allows an easy isolation of blue stained plaques. (A

detailed description of a "plaque assay" can also be found in the user's guide for insect cell culture and baculovirology distributed by Life Technologies Inc., Gaithersburg, page 9-10).

Four days after the serial dilution of the viruses was added to the cells, blue stained plaques were picked with the tip of an Eppendorf pipette. The agar containing the recombinant viruses was then resuspended in an Eppendorf tube containing 200 µl of Grace's medium. The agar was removed by a brief centrifugation and the supernatant containing the recombinant baculoviruses was used to infect Sf9 cells seeded in 35 mm dishes. Four days later the supernatants of these culture dishes were harvested and then stored at 4°C.

Sf9 cells were grown in Grace's medium supplemented with 10% heat-inactivated FBS. The cells were infected with the recombinant baculovirus V-Adrenergic Receptor at a multiplicity of infection (MOI) of 2. Six hours later the medium was removed and replaced with SF900 II medium minus methionine and cysteine (Life Technologies Inc., Gaithersburg). 42 hours later 5 µCi of ^{35}S-methionine and 5 µCi ^{35}S cysteine (Amersham) were added. The cells were further incubated for 16 hours before they were harvested by centrifugation and the labelled proteins visualized by SDS-PAGE and autoradiography.

Numerous modifications and variations of the present invention are possible in light of the above teachings and, therefore, within the scope of the appended claims, the invention may be practiced otherwise than as particularly described.

SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT: LI, ET AL.

(ii) TITLE OF INVENTION: Adrenergic Receptor

(iii) NUMBER OF SEQUENCES: 2

(iv) CORRESPONDENCE ADDRESS:

(A) ADDRESSEE: CARELLA, BYRNE, BAIN, GILFILLAN, CECCHI, STEWART & OLSTEIN
(B) STREET: 6 BECKER FARM ROAD
(C) CITY: ROSELAND
(D) STATE: NEW JERSEY
(E) COUNTRY: USA
(F) ZIP: 07068

(v) COMPUTER READABLE FORM:
(A) MEDIUM TYPE: 3.5 INCH DISKETTE
(B) COMPUTER: IBM PS/2
(C) OPERATING SYSTEM: MS-DOS
(D) SOFTWARE: WORD PERFECT 5.1

(vi) CURRENT APPLICATION DATA:
(A) APPLICATION NUMBER:
(B) FILING DATE: Submitted herewith
(C) CLASSIFICATION:

(vii) PRIOR APPLICATION DATA
(A) APPLICATION NUMBER:
(B) FILING DATE:

(viii) ATTORNEY/AGENT INFORMATION:
(A) NAME: FERRARO, GREGORY D.
(B) REGISTRATION NUMBER: 36,134
(C) REFERENCE/DOCKET NUMBER: 325800-194

(ix) TELECOMMUNICATION INFORMATION:
(A) TELEPHONE: 201-994-1700
(B) TELEFAX: 201-994-1744

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS
(A) LENGTH: 2481 BASE PAIRS
(B) TYPE: NUCLEIC ACID
(C) STRANDEDNESS: SINGLE
(D) TOPOLOGY: LINEAR

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

```
CCCTCCCAGG TTCAAGCAAT TCTCCGCCTC GGCCTCTCCA GTAGCTGGGA CTACAGTCGT   60
CCAGCATGCT CTGCCCACCC CACGCCGAGG TGCACTGACC ATGAGCCTCA ACTCCTCCCT  120
CAGCTGCAGG AAGGAGCTGA GTAATCTCAC TGAGGAGGAG GGTGGCGAAG GGGCGTCATC  180
ATCACCCAGT TCATCGCCAT CATTGTCATC ACCATTTTTG TCTGCCTGGG GAAACCTGGT  240
CATCGTGGTC ACCTTGTACA AGAAGTCCTA CCTCCTCACC CTCAGCAACA AGTTCGTCTT  300
CAGCCTGACT CTGTCCAACT TCCTGCTGTC CGTGTTGGTG CTGCCTTTTG TGGTGACGAG  360
CTCCATCCGC AGGGAATGGA TCTTTGGTGT AGTGTGGTGC AACTTCTCTG CCCTCCTCTA  420
CCTGCTGATC AGCTCTGCCA GCATGCTAAC CCTCGGGGTC ATTGCCATCG ACCGCTACTA  480
TGCTGTCCTG TACCCCATGG TGTACCCCAT GAAGATCACA GGGAACCGGG CTGTGATGGC  540
ACTTGTCTAC ATCTGGCTTC ACTCGCTCAT CGGCTGCCTG CCACCCCTGT TTGGTTGGTC  600
ATCCGTGGAG TATGGCGAGA ACAAATGGAT GTGTGTGGCT GCTTGGCACC GGGAGCCTGG  660
CTACACGGCC TTCTGGCAGA TCTGGTGTGC CCTTTTCCCC TTTCTGGTCA TGCTGGTGTG  720
CTATGGCTTC ATCTTCCGCG TGGCCAGGGT CAAGGCACGC AAGGTGCACT GTGGCACAGT  780
CGTCATCGTG GSGGSGGSTG CTCAGAGGAC CGGGAGGAAG AACTCCAGCA CCTCCACCTC  840
CTCTTCAGGG AGGAGGAGGA ATGCCTTTCA GGGTGTGGTC TACTCGGCCA ACCAGTGCAA  900
AGCCCTCATC ACCATCCTGG TGGTCCTCGG TGCCTTCATG GTCACCTGGG GCCCCTACAT  960
GGTTGTCATC GCCTCTGAGG CCCTCTGGGG GAAAAGCTCC GTCTCCCCGA GCCTGGAGAC 1020
```

```
TTGGGCCACA TGGCTGTCCT TTGCCAGCGC TGTCTGCCAC CCCCTGATCT ATGGACTCTG 1080
GAACAAGACA GTTCGCAAAG AACTACTGGG CATGTGCTTT GGGGACCGGT ATTATCGGGA 1140
ACCATTTGTG CAACGACAGA GGACTTCCAG GCTCTTCAGC ATTTCCAACA GGATCACAGA 1200
CCTGGGCCTG TCCCCACACC TCACTGCGCT CATGGCAGGC GGACAGCCCC TGGGGCACAG 1260
CAGCAGCACG GGGGACACTG GCTTCAGCTG CTCCCAGGAC TCAGGGACAG ATATGATGCT 1320
GCTTGAGGAC TACACGTCTG ATGACAACCC TCCCTCTCAC TGCACTTGCC CACCCAAGAG 1380
AAGGAGCTCG GTGACATTTG AGGATGAAGT GGAACAAATC AAAGAAGCTG CCAAGAACTC 1440
GATTCTTCAT GTGAAAGCTG AAGTACACAA GTCCTTGGAC AGTTACGCAG CAAGCTTGGC 1500
CAAAGCCATT GAGGCCGAAG CCAAAATCAA CTTATTTGGG GAGGAGGCTT TGCCAGGGGT 1560
CTTGGTTACA GCACGGACTG TCCCGGGGGG CGGCTTCGGG GGCCGCCGAG GCAGCAGAAC 1620
TCTTGTGAGC CAGAGGCTGC AGTTGCAGAG CATCGAAGAA GGAGATGTTT TAGCTGCCGA 1680
GCAGAGATGA GGGCCTCAGG GTGCCGTGGG GCTGCAGCCT GAGAGGCTGG CCCGGGGAGG 1740
AGTTCCCATC ACCGCCTGTG CCGCGGCCTT GGGAGCATGT CACTGTGTAC AGCTGGCCAC 1800
ACACAGGGAA GGAGCAGCAT CTGGTATGCA GCCACCAGGA CAAGGACTGA AAATAATGTC 1860
TACAGTCCAC AGCTTCAGCA TTTCCAGAGA CCCCATGTGA GCTTCTTTTA GGTCCCAGTG 1920
ATGGGACCAG AAGCATCTAA AGCAAAAAAA AAACCAAAAA AAATTCTAGA GATGTGTTTG 1980
TGGCTTTTGG GGAGGTGGGG CATGGGAGGA CCAGAGACGA AGGGTTTGGA AGGAGACCCC 2040
CACATGCATC ATTTCCTCCT CTTCACAGTG TGCTGGGAGT CCAGCCGTGC ACTGTGCCAG 2100
ATGCCTCAGG AGGAGAACCC TCCCCAGTGT ACTGTGAAGG ATGAACACAG AACTTCTTCC 2160
TAATGAAACG CGACCGTCCT GGTGTCTCTA CATGGTTGAT GCGGACAGTG TGGGACCCTC 2220
AGTTCTAGGA CTGGTCCGCA GAGAATTTAC CCAGGTGCAG TGCGCTTCGG AGCGGTCCTC 2280
AGTGGCGGCA CCTGTTGGTG TTAATAGGGA CAGACACAGG CCTCTTGCAG TCTGGACCAC 2340
CCTGTCTACT TCCCTACTTA AAAGGTCTTG GGTATTTCAA AAGGGAGAAA CCACTTATAA 2400
TAGTGAAGTT GGTAGGGCAG TACTACTCTG TTTCATTTCC AGAATTAAAA AAAAAATAAA 2460
TATTATTCCT GCGGCCTGTT A                                          2481
```

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS

(A) LENGTH: 529 AMINO ACIDS

(B) TYPE: AMINO ACID

(C) STRANDEDNESS:

(D) TOPOLOGY: LINEAR

(ii) MOLECULE TYPE: PROTEIN

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

```
Met Ser Leu Asn Ser Ser Leu Ser Cys Arg Lys Glu Leu Ser Asn
 5                  10                  15
```

Leu Thr Glu Glu Glu Gly Gly Glu Gly Ala Ser Ser Ser Pro Ser
20 25 30
Ser Ser Pro Ser Leu Ser Ser Pro Phe Leu Ser Ala Trp Gly Asn
35 40 45
Leu Val Ile Val Val Thr Leu Tyr Lys Lys Ser Tyr Leu Leu Thr
50 55 60
Leu Ser Asn Lys Phe Val Phe Ser Leu Thr Leu Ser Asn Phe Leu
65 70 75
Leu Ser Val Leu Val Leu Pro Phe Val Val Thr Ser Ser Ile Arg
80 85 90
Arg Glu Trp Ile Phe Gly Val Val Trp Cys Asn Phe Ser Ala Leu
95 100 105
Leu Tyr Leu Leu Ile Ser Ser Ala Ser Met Leu Thr Leu Gly Val
110 115 120
Ile Ala Ile Asp Arg Tyr Tyr Ala Val Leu Tyr Pro Met Val Tyr
125 130 135
Pro Met Lys Ile Thr Gly Asn Arg Ala Val Met Ala Leu Val Tyr
140 145 150
Ile Trp Leu His Ser Leu Ile Gly Cys Leu Pro Pro Leu Phe Gly
155 160 165
Trp Ser Ser Val Glu Tyr Gly Glu Asn Lys Trp Met Cys Val Ala
170 175 180
Ala Trp His Arg Glu Pro Gly Tyr Thr Ala Phe Trp Gln Ile Trp
185 190 195
Cys Ala Leu Phe Pro Phe Leu Val Met Leu Val Cys Tyr Gly Phe
200 205 210
Ile Phe Arg Val Ala Arg Val Lys Ala Arg Lys Val His Cys Gly
215 220 225
Thr Val Val Ile Val Glu Glu Asp Ala Gln Arg Thr Gly Arg Lys
230 235 240
Asn Ser Ser Thr Ser Thr Ser Ser Ser Gly Arg Arg Arg Asn Ala
245 250 255
Phe Gln Gly Val Val Tyr Ser Ala Asn Gln Cys Lys Ala Leu Ile
260 265 270

```
Thr Ile Leu Val Val Leu Gly Ala Phe Met Val Thr Trp Gly Pro
                275                 280                 285
Tyr Met Val Val Ile Ala Ser Glu Ala Leu Trp Gly Lys Ser Ser
                290                 295                 300
Val Ser Pro Ser Leu Glu Thr Trp Ala Thr Trp Leu Ser Phe Ala
                305                 310                 315
Ser Ala Val Cys His Pro Leu Ile Tyr Gly Leu Trp Asn Lys Thr
                320                 325                 330
Val Arg Lys Glu Leu Leu Gly Met Cys Phe Gly Asp Arg Tyr Tyr
                335                 340                 345
Arg Glu Pro Phe Val Gln Arg Gln Arg Thr Ser Arg Leu Phe Ser
                350                 355                 360
Ile Ser Asn Arg Ile Thr Asp Leu Gly Leu Ser Pro His Leu Thr
                365                 370                 375
Ala Leu Met Ala Gly Gly Gln Pro Leu Gly His Ser Ser Ser Thr
                380                 385                 390
Gly Asp Thr Gly Phe Ser Cys Ser Gln Asp Ser Gly Thr Asp Met
                395                 400                 405
Met Leu Leu Glu Asp Tyr Thr Ser Asp Asp Asn Pro Pro Ser His
                410                 415                 420
Cys Thr Cys Pro Pro Lys Arg Arg Ser Ser Val Thr Phe Glu Asp
                425                 430                 435
Glu Val Glu Gln Ile Lys Glu Ala Ala Lys Asn Ser Ile Leu His
                440                 445                 450
Val Lys Ala Glu Val His Lys Ser Leu Asp Ser Tyr Ala Ala Ser
                455                 460                 465
Leu Ala Lys Ala Ile Glu Ala Glu Ala Lys Ile Asn Leu Phe Gly
                470                 475                 480
Glu Glu Ala Leu Pro Gly Val Leu Val Thr Ala Arg Thr Val Pro
                485                 490                 495
Gly Gly Gly Phe Gly Gly Arg Arg Gly Ser Arg Thr Leu Val Ser
                500                 505                 510
Gln Arg Leu Gln Leu Gln Ser Ile Glu Glu Gly Asp Val Leu Ala
                515                 520                 525
Ala Glu Gln Arg
```

WHAT IS CLAIMED IS:

1. An isolated polynucleotide selected from the group consisting of:

(a) a polynucleotide encoding the G-protein coupled receptor polypeptide having the deduced amino acid sequence of Figure 1 or a fragment, analog or derivative of said polypeptide;

(b) a polynucleotide encoding the G-protein coupled receptor polypeptide having the amino acid sequence encoded by the cDNA contained in ATCC Deposit No. 75822 or a fragment, analog or derivative of said polypeptide.

2. The polynucleotide of Claim 1 wherein the polynucleotide is DNA.

3. The polynucleotide of Claim 1 wherein the polynucleotide is RNA.

4. The polynucleotide of Claim 1 wherein the polynucleotide is genomic DNA.

5. The polynucleotide of Claim 2 wherein said polynucleotide encodes G-protein coupled receptor having the deduced amino acid sequence of Figure 1.

6. The polynucleotide of Claim 2 wherein said polynucleotide encodes the G-protein coupled receptor polypeptide encoded by the cDNA of ATCC Deposit No. 75822.

7. The polynucleotide of Claim 1 having the coding sequence of G-protein coupled receptor as shown in Figure 1.

8. The polynucleotide of Claim 2 having the coding sequence of G-protein coupled receptor deposited as ATCC Deposit No. 75822.

9. A vector containing the DNA of Claim 2.

10. A host cell genetically engineered with the vector of Claim 9.

11. A process for producing a polypeptide comprising: expressing from the host cell of Claim 10 the polypeptide encoded by said DNA.

12. A process for producing cells capable of expressing a polypeptide comprising genetically engineering cells with the vector of Claim 9.

13. An isolated DNA hybridizable to the DNA of Claim 2 and encoding a polypeptide having G-protein coupled receptor activity.

14. A polypeptide selected from the group consisting of (i) a G-protein coupled receptor polypeptide having the deduced amino acid sequence of Figure 1 and fragments, analogs and derivatives thereof and (ii) a G-protein coupled receptor polypeptide encoded by the cDNA of ATCC Deposit No. 75822 and fragments, analogs and derivatives of said polypeptide.

15. The polypeptide of Claim 14 wherein the polypeptide is a G-protein coupled receptor having the deduced amino acid sequence of Figure 1.

16. An antibody against the polypeptide of claim 14.

17. A compound which inhibits activation of the G-protein coupled receptor polypeptide of claim 14.

18. A method for the treatment of a patient having need of a activation of a G-protein coupled receptor polypeptide of claim 14 comprising: administering to the patient a therapeutically effective amount of a compound which activates the receptor of the G-protein coupled receptor of Claim 14.

19. A method for the treatment of a patient having need to inhibit activation of the G-protein coupled receptor of claim 14 comprising: administering to the patient a therapeutically effective amount of a compound which inhibits activation of the G-protein coupled receptor of Claim 17.

20. The polypeptide of Claim 14 wherein the polypeptide is a soluble fragment of the G-protein coupled receptor and is capable of binding a ligand for the receptor.

21. A process for identifying antagonists and agonists to the G-protein coupled receptor comprising:

expressing the G-protein coupled receptor on the surface of a cell;

contacting the cell with a receptor ligand and compound to be screened;

determining whether a second signal is generated from the interaction of the ligand and the receptor; and

identifying if the compound to be screened is an agonist or antagonist.

22. A process for determining whether a ligand not known to be capable of binding to a G-protein coupled receptor can bind thereto comprising:

contacting a mammalian cell which expresses the G-protein coupled receptor with a potential ligand;

detecting the presence of the ligand which binds to the receptor; and

determining whether the ligand binds to the G-protein coupled receptor.

FIG. 1A

```
          10                  30                  50
CCCTCCCAGGTtCAAgCAATtcTCCgCcTCGGCCTCTCCAGTAGCTGGGACTACAGTCGT
          70                  90                 110
CCAGcATGCTCTGCCCACCCCACgCCGAGgTGCACTGACCATGAGCCTCAACTCCTCCCT
                                                M  S  L  N  S  S  L
         130                 150                 170
CAGCTGCAGGAAGGAGCTGAGTAATCTCACTGAGGAGGAGGGTGgCGAaGGGGCGTCATC
 S  C  R  K  E  L  S  N  L  T  E  E  E  G  G  E  G  A  S  S
         190                 210                 230
ATCACCCAGTTCATCGCCATCATTGTCATCACCATTTtTGTCTGCCTGGGgAAACCTGGT
 S  P  S  S  S  P  S  L  S  S  P  F  L  S  A  W  G  N  L  V
         250                 270                 290
CATCGTGGTCACCTTGTACAAGAAGTCCTACCTCCTCACCCTCAGcAACAAGTTCGTCTT
 I  V  V  T  L  Y  K  K  S  Y  L  L  T  L  S  N  K  F  V  F
         310                 330                 350
CAGCCTGACTCTGTCCAACTTCCTGCTGTCCGTGTTGGTGCTGCCTttGTGGTGACGAg
 S  L  T  L  S  N  F  L  L  S  V  L  V  L  P  F  V  V  T  S
         370                 390                 410
CTCCATCCGcAGGGAATGgatCTTTGGTGTAgTGTGGTGCAAcTTCTCTgCCCTCCTCTA
 S  I  R  R  E  W  I  F  G  V  V  W  C  N  F  S  A  L  L  Y
         430                 450                 470
CCTGcTGATCAGCtCTGCCAGCATGCTAACCCTCGGGGTCATTGCCATCGACCGCTACTA
 L  L  I  S  S  A  S  M  L  T  L  G  V  I  A  I  D  R  Y  Y
         490                 510                 530
TGcTGTCCTGTaCCCCATGGTGTaCCCCATGAAGAtCACAGGGAACCGGgCTGTGATGGC
 A  V  L  Y  P  M  V  Y  P  M  K  I  T  G  N  R  A  V  M  A
         550                 570                 590
```

MATCH WITH FIG. 1B

MATCH WITH FIG. 1A

FIG. 1B

```
ACTTGTCTACAtCTgGCttCACTCGCTCATCGGCTGCCTTGCCACCCTGTttGGTTGGTC
 L  V  Y  I  W  L  H  S  L  I  G  C  L  P  P  L  F  G  W  S
       610                  630                  650
ATCCGTGGAGTATGgCGAGaaCAAATGGATGTGTGTGGCTGCTTGgCAccGGGAGCCTGG
 S  V  E  Y  G  E  N  K  W  M  C  V  A  A  W  H  R  E  P  G
       670                  690                  710
CtACACGgCCTTCTGGCAGAtCTGGTGTGCCCTTTTCCCCTTTCTGGTCATGCTGGTGTG
 Y  T  A  F  W  Q  I  W  C  A  L  F  P  F  L  V  M  L  V  C
       730                  750                  770
CTATGGCttCATCttcCGCGTGgCCAGGgtCAAGGcACGCAAGGTGCACTGTGGCACAGT
 Y  G  F  I  F  R  V  A  R  V  K  A  R  K  V  H  C  G  T  V
       790                  810                  830
CGTCATCGTGGAGGAGGATGCTCAGAGGACCGGGAGGAAGAACTCCAGCACCTCCACCTC
 V  I  V  E  E  D  A  Q  R  T  G  R  K  N  S  S  T  S  T  S
       850                  870                  890
CTCTTCAGGgAGgAGGAGGAATGCCTTTCAGGGTGTGGTCTACTCGGCCAACCAGTGCAA
 S  S  G  R  R  R  N  A  F  Q  G  V  V  Y  S  A  N  Q  C  K
       910                  930                  950
AGCCCTCATCACCATCCTGGTGGTCCTCGGTGCCTTCATGGTCACCTGGGGCCCCTACAT
 A  L  I  T  I  L  V  V  L  G  A  F  M  V  T  W  G  P  Y  M
       970                  990                  1010
GGTTGTcATCGCCTCTgAGGCCCTCTGGGGGAAAAGCTCCGTCTCCCCGAGCCTGGAGAC
 V  V  I  A  S  E  A  L  W  G  K  S  S  V  S  P  S  L  E  T
     1030                 1050                 1070
TTGGGCCACATGGCTGTCCTTTGCCAGCGCTGTCTGCCACCCCCTGATCTATGGACTCTG
 W  A  T  W  L  S  F  A  S  A  V  C  H  P  L  I  Y  G  L  W
```

MATCH WITH FIG. 1C

MATCH WITH FIG. 1B

FIG. 1C

```
      1090                 1110                 1130
GAACAAGACAGTTCGCAAAGAACTACTGGGCATGTGCTTTGGGGACCGGTATTATCGGGA
 N  K  T  V  R  K  E  L  L  G  M  C  F  G  D  R  Y  Y  R  E
      1150                 1170                 1190
ACCATTTGTGCAACGACAGAGGACTTCCAGGCTCTTCAGCATTTCCAACAGGATCACAGA
 P  F  V  Q  R  Q  R  T  S  R  L  F  S  I  S  N  R  I  T  D
      1210                 1230                 1250
CCTGGGCCTGTCCCCACACCTCACTGCGCTCATGGCAGGCGGACAGCCCCTGGGGCACAG
 L  G  L  S  P  H  L  T  A  L  M  A  G  G  Q  P  L  G  H  S
      1270                 1290                 1310
CAGCAGCACGGGGGACACTGGCTTCAGCTGCTCCCAGGACTCAGGGACAGATATGATGCT
 S  S  T  G  D  T  G  F  S  C  S  Q  D  S  G  T  D  M  M  L
      1330                 1350                 1370
GCTTGAGGACTACACGTCTGATGACAACCCTCCCTCTCACTGCACTTGCCCACCCAAGAG
 L  E  D  Y  T  S  D  D  N  P  P  S  H  C  T  C  P  P  K  R
      1390                 1410                 1430
AAGGAGCTCGGTGACATTTGAGGATGAAGTGGAACAAATCAAAGAAGCTGCCAAGAACTC
 R  S  S  V  T  F  E  D  E  V  E  Q  I  K  E  A  A  K  N  S
      1450                 1470                 1490
GATTCTTCATGTGAAAGCTGAAGtACACAAGTCCTTGGACAGTTACGCAGCAAGCTTGGC
 I  L  H  V  K  A  E  V  H  K  S  L  D  S  Y  A  A  S  L  A
      1510                 1530                 1550
CaAAGcCATTGAGGCCGAAGCCaAAATCAACTTATTTGGGGAGGAGGCTTTgCCAGGGGT
 K  A  I  E  A  E  A  K  I  N  L  F  G  E  E  A  L  P  G  V
      1570                 1590                 1610
CTTGGTT AGCACGGACTGTCCCGGGGGGCGGCTTCGGGGGCCgCCGAGGCAGCAGAAC
```

MATCH WITH FIG. 1D

MATCH WITH FIG. IC

FIG. ID

```
 L  V  T  A  R  T  V  P  G  G  G  F  G  G  R  R  G  S  R  T
      1630                 1650                 1670
TCTTGTGAGCCAGAGGCTGCAGTTGCAGAGCATCGAAGAAGGAGATGTTTTAgCTgCCGA
 L  V  S  Q  R  L  Q  L  Q  S  I  E  E  G  D  V  L  A  A  E
      1690                 1710                 1730
GCAGAGATGAGGGCCTCAGGGTGCCGTGGGGCTGCAGCCTGAGAGGCTGGCCCGGGGAGG
 Q  R  *
      1750                 1770                 1790
AGTTCCCATCACCGCCTGTgcCGCGGCCTTGGGAGCATGTCACTGTGTACAGCTGGCCAC
      1810                 1830                 1850
ACACAGGGAAGGAGCAGCATCTGGTATGCAgCCACCAGGACAAGGACTGAAAATAATGTC
      1870                 1890                 1910
TACAGTCCACAGCTTCAGCATTTCCAGAGACCaCATGTGAGCtTCTtTTAGGTCCCAgTG
      1930                 1950                 1970
AtGGGACCAgAAGCatCTAAAgCAAAAAAAAAaCCAAAaAAAAtTCTAgAgATGTGttTG
      1990                 2010                 2030
TGgCTTTTgGGGAGgTGGGGCATGGgAGGACCAgAGACGAaGGGtTTGgAAGGAGACCCC
      2050                 2070                 2090
CACATGCATCATTTCCTCCTCTTCACAGTGTGCTGGgAGTCCAGCCGTGCACTGTGCCAG
      2110                 2130                 2150
ATgCCTCAGGAGGAGAACCCTCCCCAGTGTACTGTGAAGGATGAaCACAgaACTTCTTCC
      2170                 2190                 2210
TAATGAAACGCGACCGTCCTGGTGtCTCTaCATGGTTGATGCGgaCAGTGTGGGAcCCTC
```

MATCH WITH FIG. IE

MATCH WITH FIG. 1D

FIG. 1E

```
      2230                    2250                    2270
AGttcTaGgAcTGGtCCGCAGaGAAtttACCCaGGtGcAGtGCGCTTCGGAGcGGTCCTC
      2290                    2310                    2330
AgtGGCGgCaCCTGtTGgTGtTaATAGGGAcAGaCACAGGCCTCTTGcAGtcTgGaCCaC
      2350                    2370                    2390
CCtgtctacTTCCCTAcTTAaAAGgTctTgGGTatttcAAaaGGGAgaaaccacttAtAA
      2410                    2430                    2450
taGtgaagttggtaGggcaGTACTActcTGTTTcATTTCCAGAATTAAAAAAAAAAtAAA
      2470
tAttATtCCTGCGGCCtGTtA
```

MATCH WITH FIG. 2A

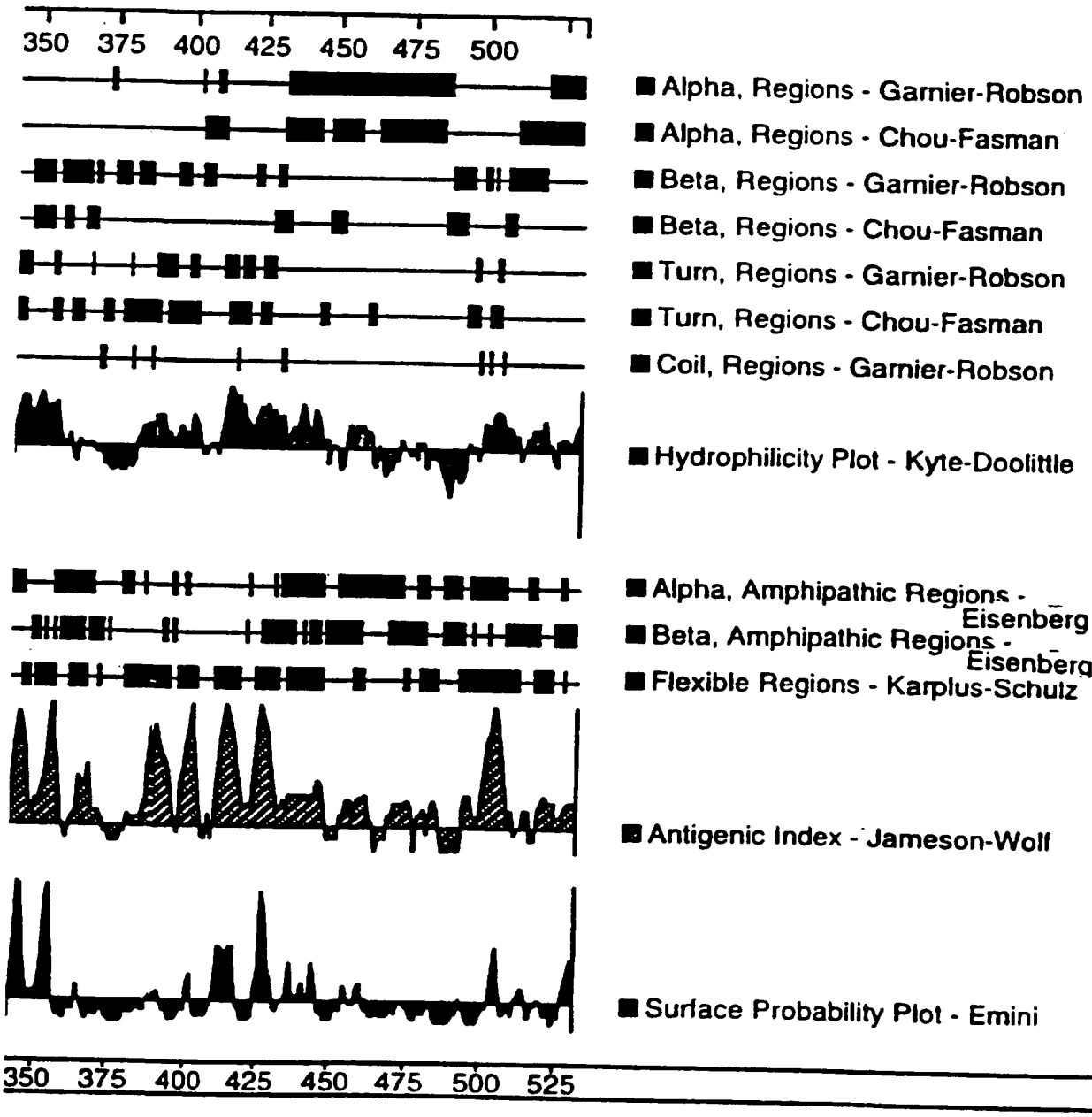


FIG. 2B

MATCH WITH FIG. 2B

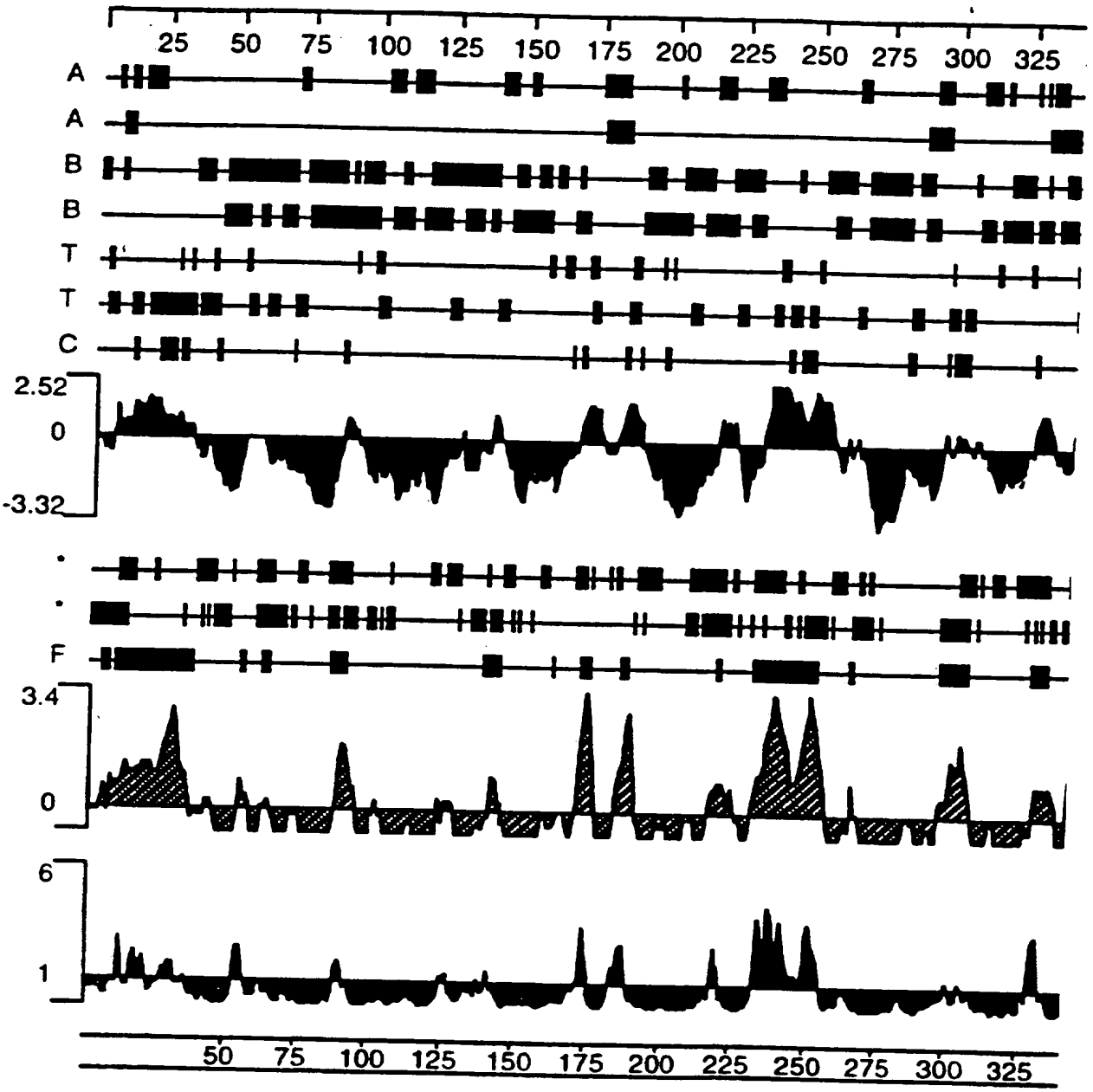
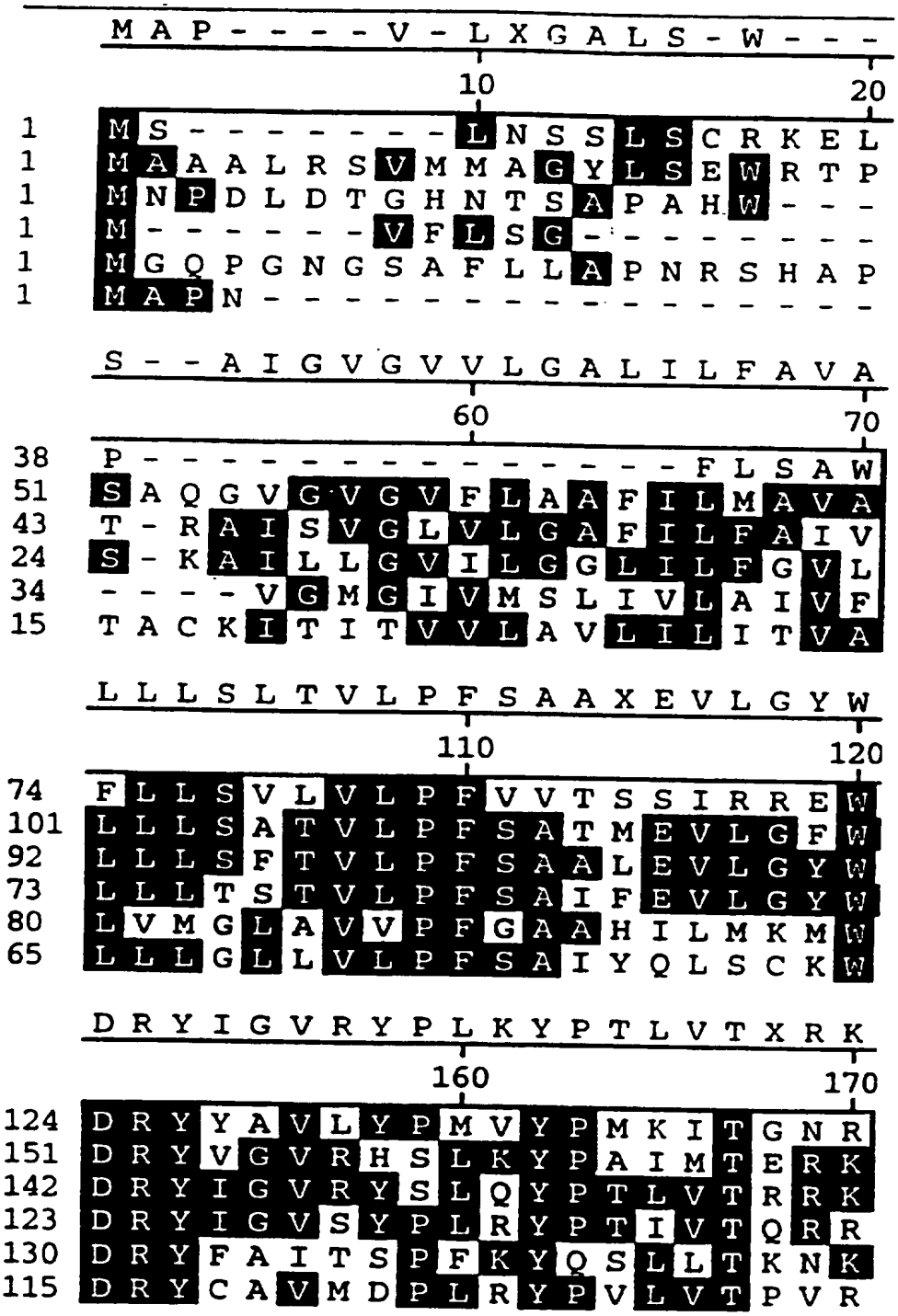


FIG. 2A



MATCH WITH FIG. 3Ab

FIG. 3Aa

SUBSTITUTE SHEET (RULE 26)

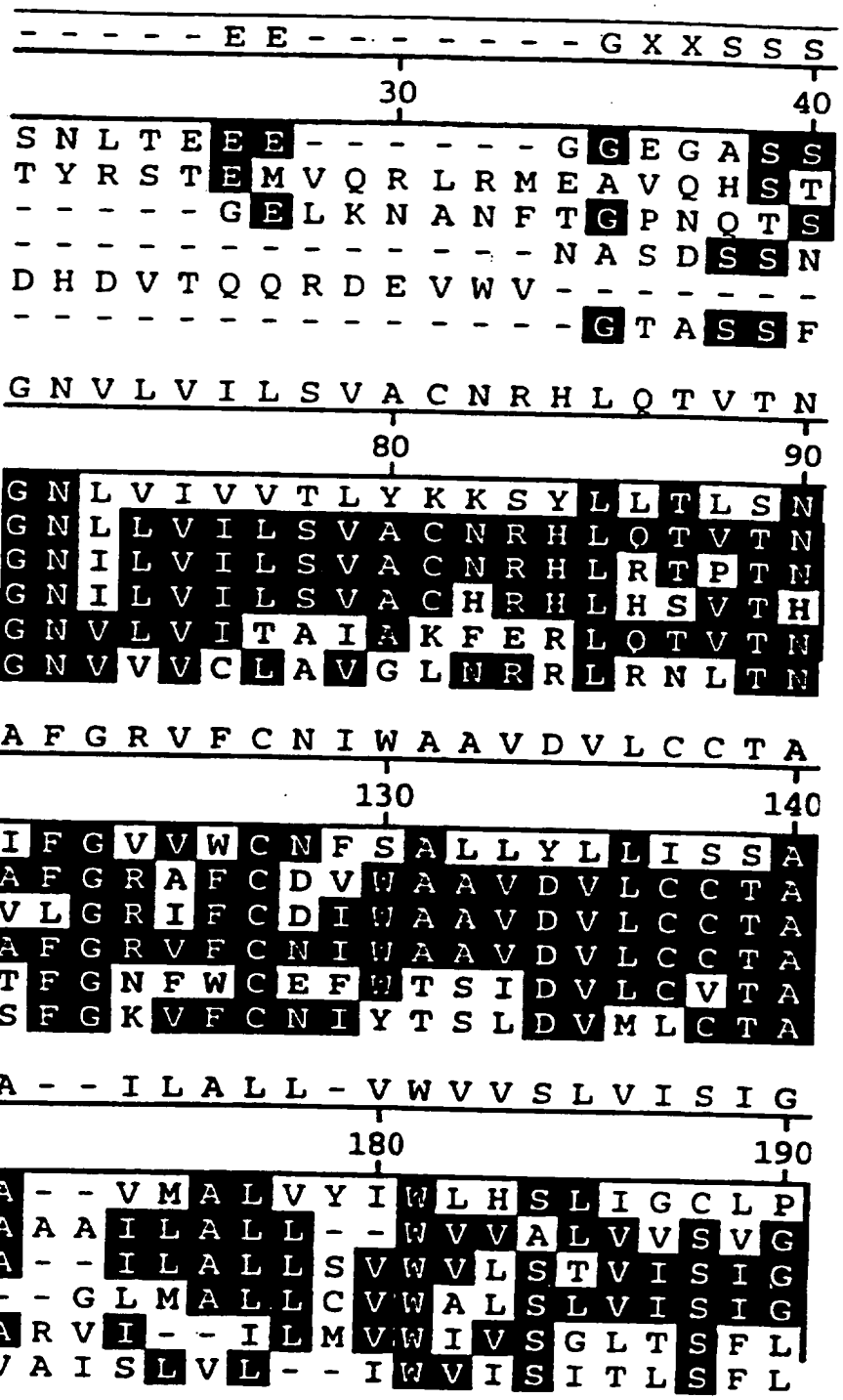
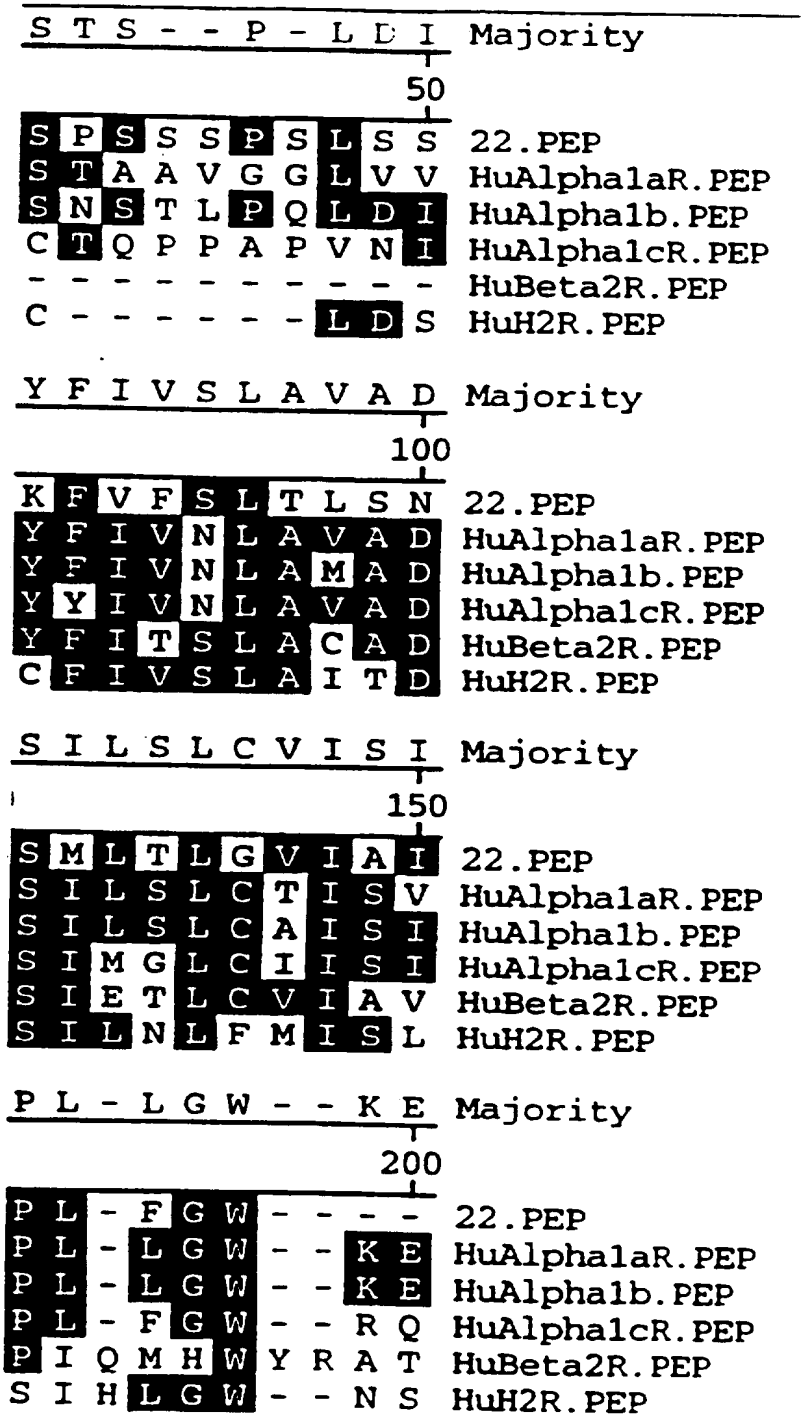
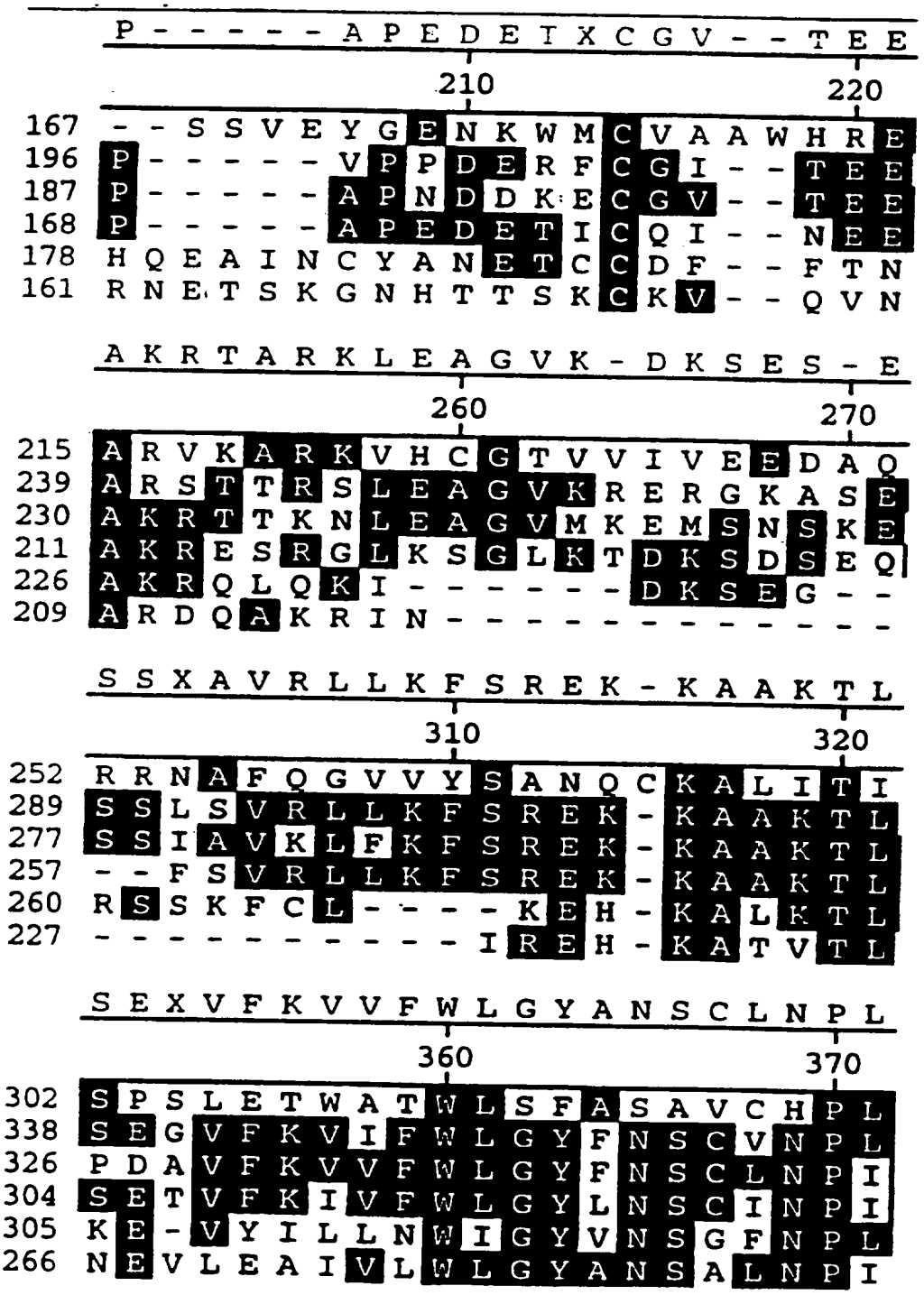


FIG. 3Ab



MATCH WITH FIG. 3Ab

FIG. 3Ac



MATCH WITH FIG. 3B b

FIG. 3Ba

SUBSTITUTE SHEET (RULE 26)

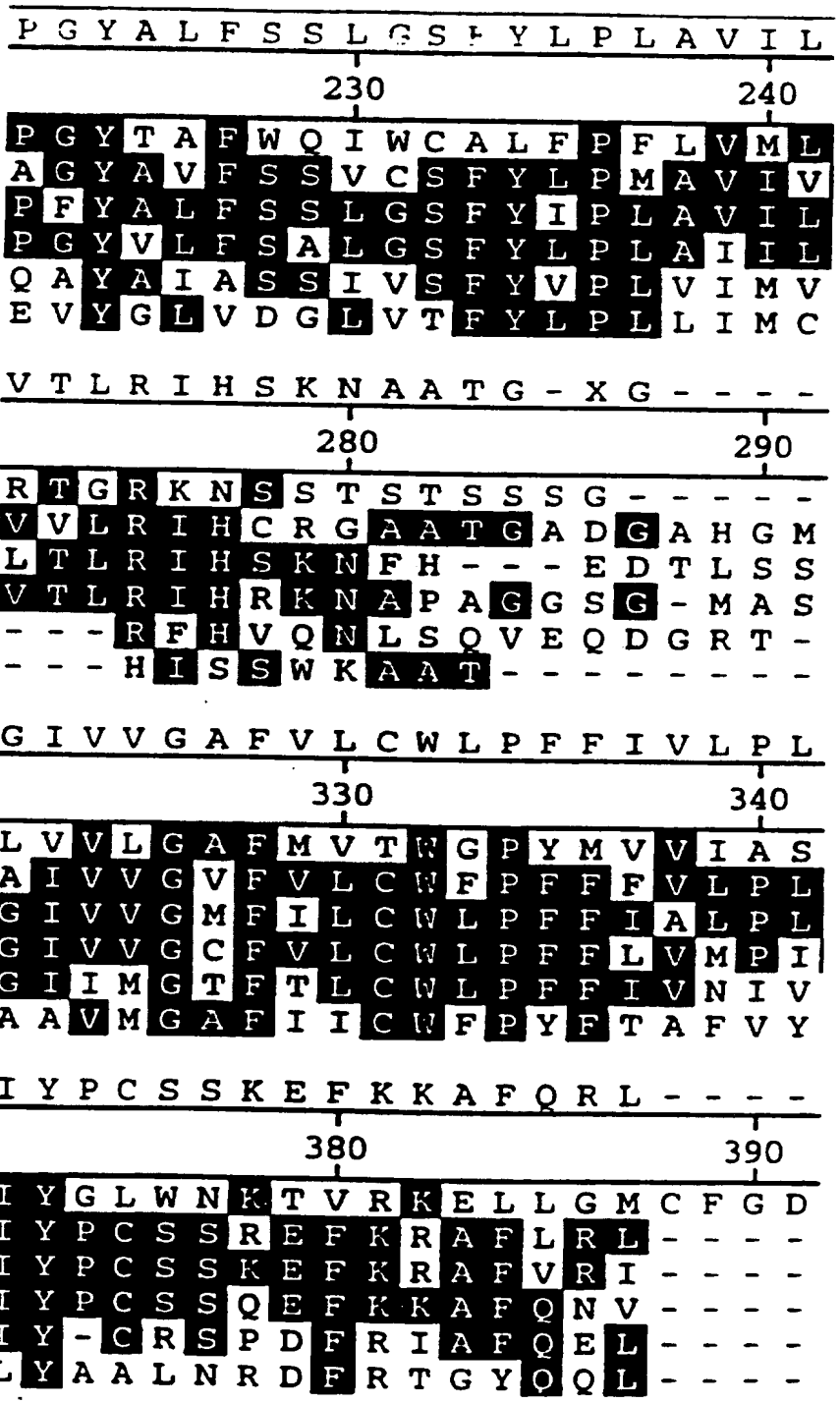


FIG. 3Bb

MATCH WITH FIG. 3B b

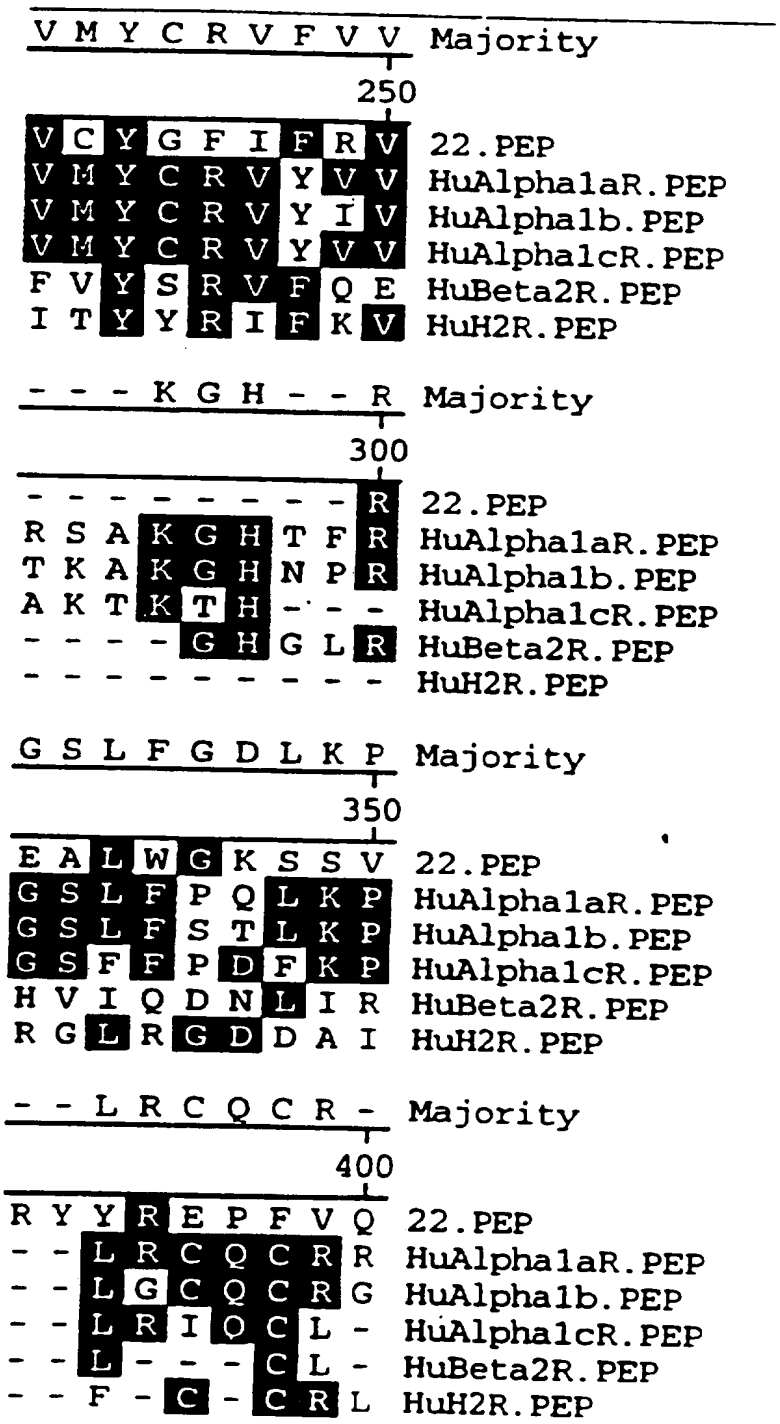
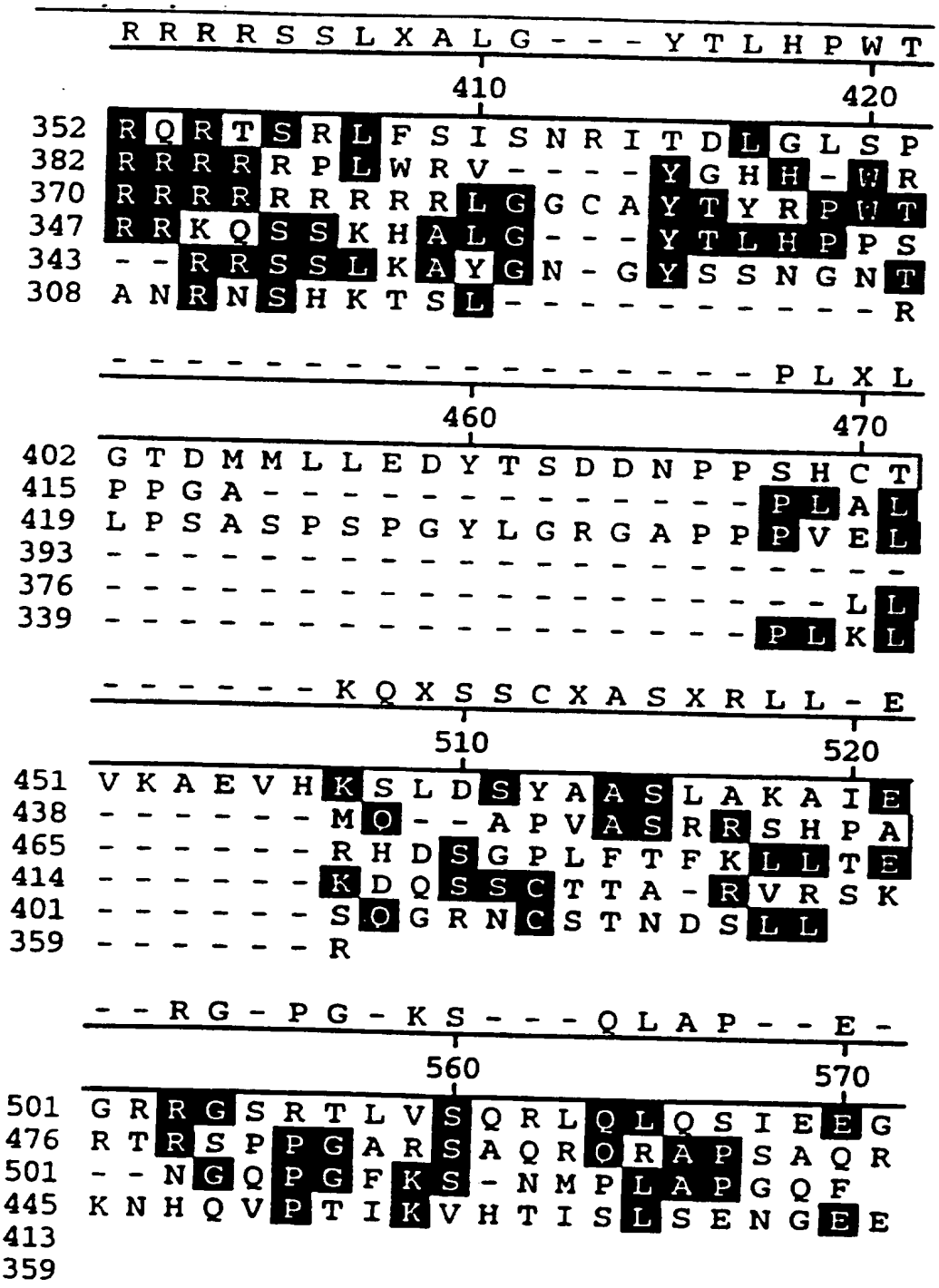


FIG. 3Bc



MATCH WITH FIG. 3Cb

Decoration 'Decoration #1': Shaded with solid residues that match the Consensus exactly.

FIG. 3Ca

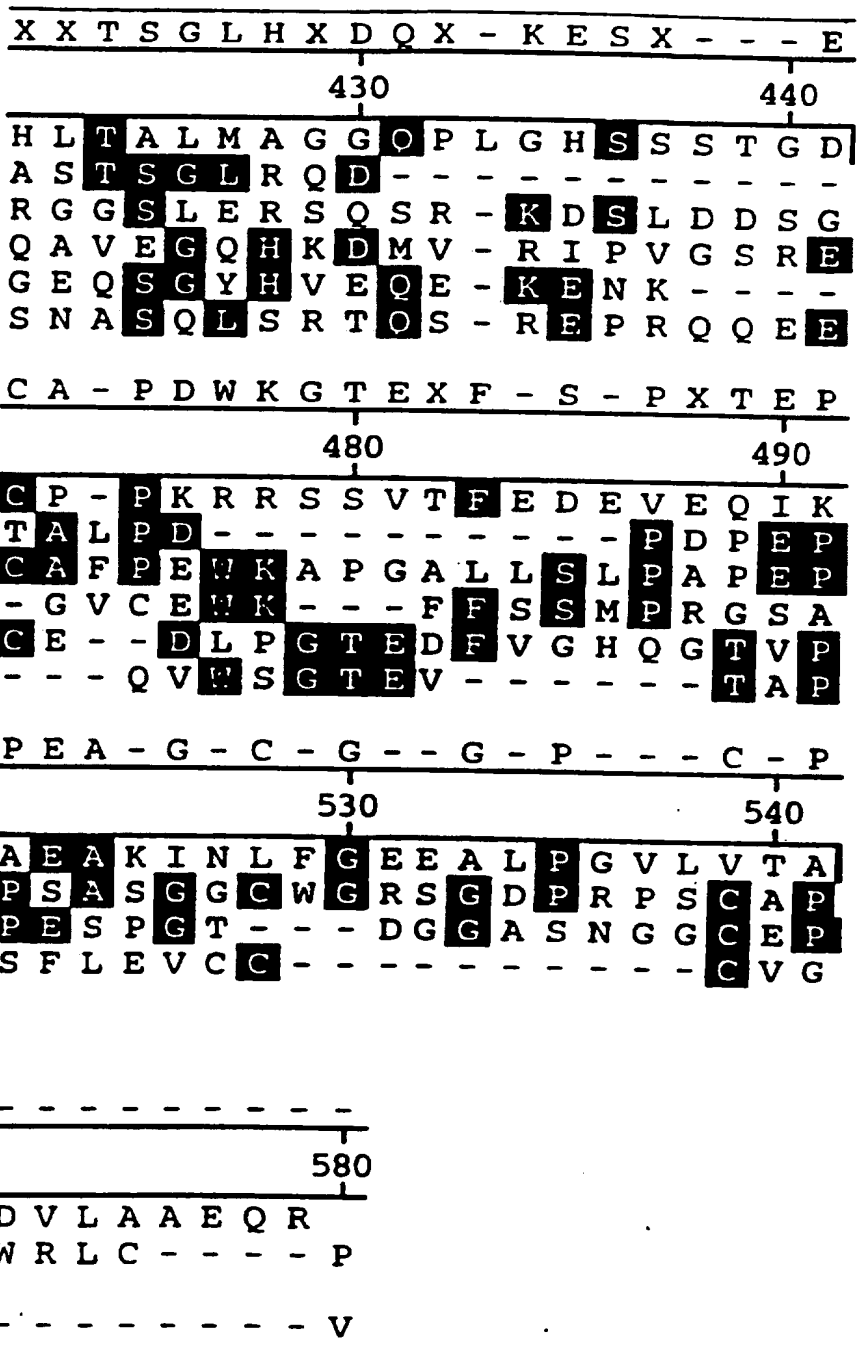
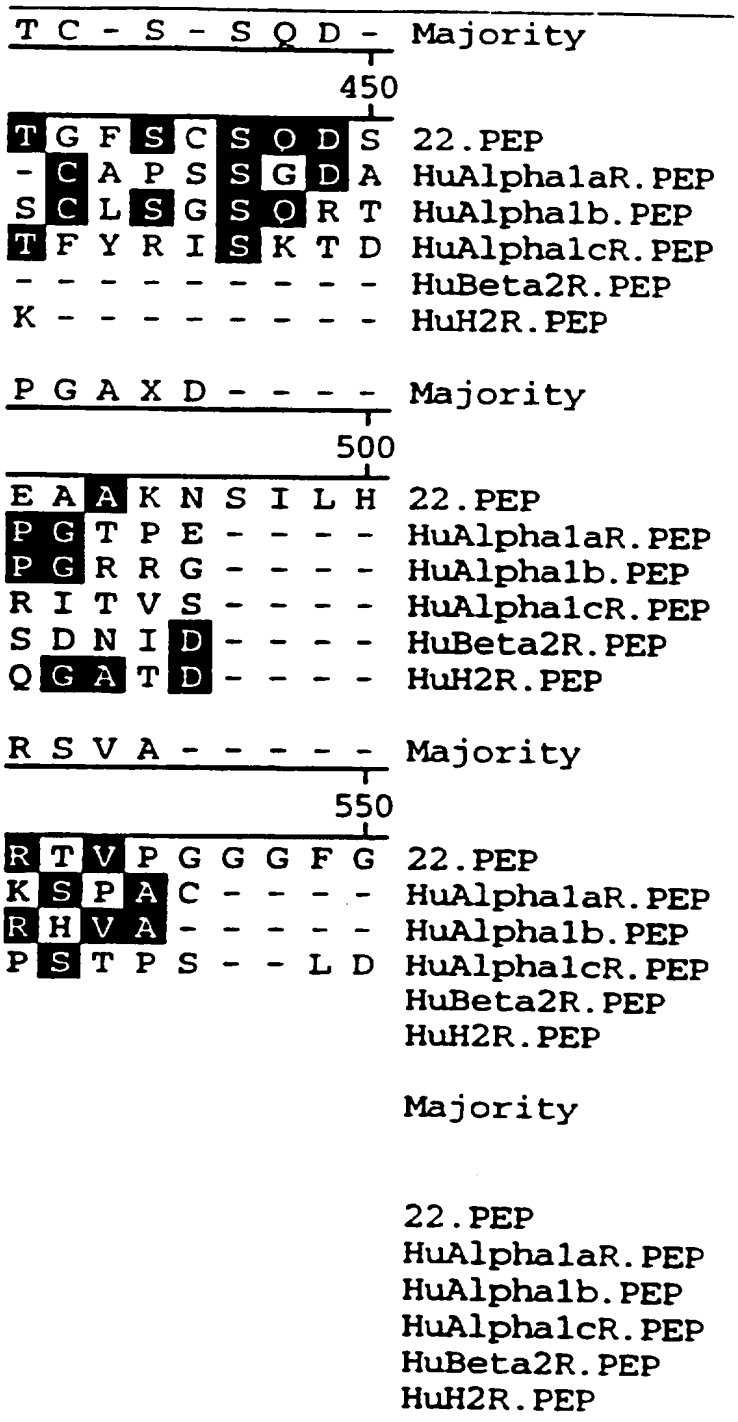


FIG. 3Cb



MATCH WITH FIG. 3Cb

FIG. 3Cc

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/09051

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :C07K 14/705, 16/00; C12N 15/09; C12P 1/00; A61K 38/17
US CL :435/69.1, 240.1, 320.1; 514/12; 530/350, 388.1; 536/23.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 435/69.1, 240.1, 320.1; 514/12; 530/350, 388.1; 536/23.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
APS, BIOSIS, MEDLINE, WPI
search terms: adrenergic receptor, G-protein coupled receptor, antagonists, agonists

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,288,607 (EMORINE ET AL.) 22 February 1994, see entire document.	1-21
Y	Molecular Pharmacology, Volume 40, issued December 1991, Granneman et al, "Molecular Cloning and Expression of the Rat β_3-Adrenergic Receptor", pages 895-899, see pages 896-898.	1-21
Y	The Journal of Biological Chemistry, Volume 266, No. 10, issued 05 April 1991, Lomasney et al, "Molecular Cloning and Expression of the cDNA for the α_{1A}-Adrenergic Receptor", pages 6365-6369, see pages 6366-6368.	1-21

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
04 NOVEMBER 1994

Date of mailing of the international search report
28 NOV 1994

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No (703) 305-3230

Authorized officer
Sally P. Teng

Telephone No (703) 308-0196

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/09051

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	The Journal of Biological Chemistry, Volume 264, No. 20, issued 15 July 1989, Fraser et al. "Cloning, Sequence Analysis, and Permanent Expression of a Human α_2-Adrenergic Receptor in Chinese Hamster Ovary Cells", pages 11754-11761, see pages 11755-11760.	1-21